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KALGOORLIE TELLURIDES.

We have just received the following rare species (massive) from our collector who made a six months' trip through Western Australia, visiting the principal mining districts:

Coloradoite, Telluride of Mercury.
Kalgoorlite, Telluride of Mercury, Gold and Silver.
Coolgardite, Telluride of Mercury, Gold and Silver.
Calaverite, Telluride of Gold.

FROM GREENBUSHES.

Stibiotantalite, Tantalo-niobate of Antimony.
Tantalite, Large masses, some intimately associated with Stibiotantalite.

JOPLIN.

Amethystine Iceland Spar, Twin Crystals. We obtained last winter of the finder, a selection from this latest discovery, and supplied a number of the principal museums with specimens which were highly prized. Besides the remaining perfect crystals, weighing from ½ to 60 lbs., the twinned cleavages are much in demand.

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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. I.—*Atmospheric Radio-activity;* by H. A. Bumstead.

It has recently been shown by a number of investigations, made in widely separated localities, that the radio-active gas obtained from the earth, from water, and from petroleum, has the same properties as the emanation from radium.* Some of the emanation must of course be present also in the air above-ground, and it is an immediate inference that the radio-active phenomena of the atmosphere may be due to its presence. Thus one might expect that the activity deposited upon a negatively-charged wire when it is exposed in the open air would decay at the same rate as the excited activity due to radium, and Elster and Geitel have recently made some measurements† which confirm this expectation, at least approximately. On the other hand, Rutherford and Allan,‡ who were the first to investigate carefully the rate of decay of the negatively-charged wire, obtained a different result; they found that the activity falls off regularly according to an exponential law and reaches half-value in about 45 minutes, whereas the radium-induced activity does not fall off exponentially during the first two hours, and, when it does begin to do so, its half-value time is 28 minutes instead of 45. Quite recently, Allan has made an extended study of atmospheric radio-activity§ in the course of which he has, in the main, confirmed the previous results obtained by Rutherford and himself with regard to the rate of decay, although certain observations point to the conclusion that the decay is not entirely regular.

* Adams, Phil. Mag., Nov. 1903; Elster and Geitel, Phys. Zeitschr., v, p. 11, 1904; Bumstead and Wheeler, this Journal, Feb. 1904; Himstedt, Drud. Ann., xiii, p. 573, 1904.

† Elster and Geitel, loc. cit.

‡ Rutherford and Allan, Phil. Mag., Dec. 1902.

§ Allan, Phil. Mag., Feb. 1904.

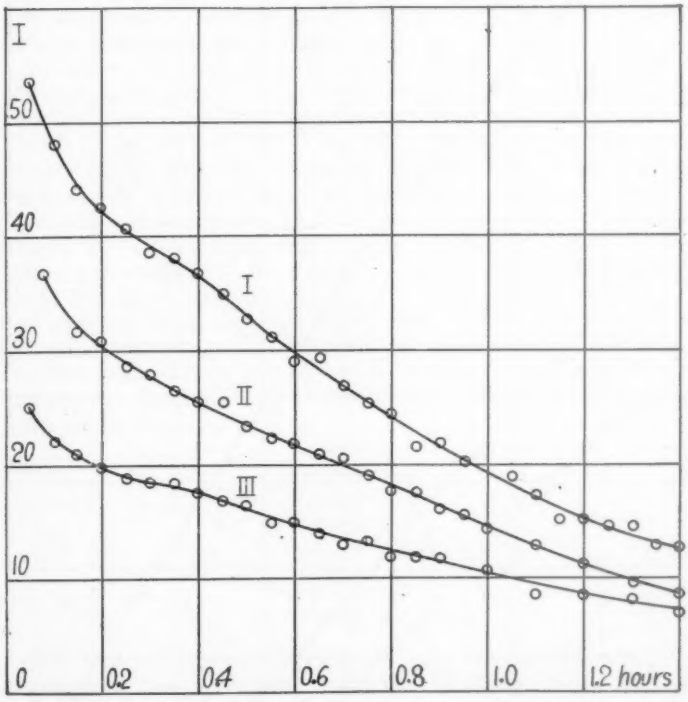
The experiments which I am about to describe were begun before the appearance of the recent papers by Elster and Geitel and by Allan, and were continued in view of the discrepancy between their results, and also because indications had been obtained of results not observed by either. A fine copper wire $\frac{1}{4}^{mm}$ in diameter was suspended horizontally, about 8 meters above the ground, between two neighboring buildings; it was attached to the negative pole of a Wimshurst machine, driven by a small motor, the positive pole of the Wimshurst being earthed. A parallel spark-gap 5^{mm} long served to keep the potential-difference constant during an exposure which was usually continued for three hours. The activity of the wire was observed in a cylindrical testing vessel, with the central rod connected to one pair of quadrants of an electrometer; the rod was protected by an earthed guard-plate in the usual manner. The bottom of the testing vessel was easily removable and bore four vertical brass rods just within the walls of the cylinder, and about these rods the exposed wire could be wound. The electrometer was of special construction, with sulphur insulation and adjustable quadrants; the needle was of silvered paper and the suspension a quartz fiber dipped in a solution of calcium chloride to render it conducting, as in Dolezalek's electrometer. With the suspension used and 90 volts on the needle, the sensitiveness was sufficient (250^{cm} per volt with the scale at one meter), and the instrument was very steady. When the potential on the needle was kept constant, the sensitiveness of the apparatus to a small sample of uranium oxide did not vary appreciably over a period of several days. Accidental motions of the needle were largely avoided by enclosing the connecting wire between electrometer and cylinder in an earthed brass box, outside of which a small electromagnet served to insulate or short circuit the quadrants.* The exposed wire could be put into the cylinder without disturbing the connections or jarring the electrometer, so that readings could be begun immediately; the only time lost after the end of the exposure was in taking in the wire and winding it about the frame. After the wire had been put into the testing vessel, measurements of the ionization current were made at intervals of three minutes during the first part of the experiment when the change in activity was rapid; later, readings were taken every six minutes.

In the earlier experiments, comparatively short wires were exposed (5 meters) and the decay of the activity of these could be followed with some accuracy for about two hours. The similarity to the behavior of the excited activity due to radium

* This arrangement has been previously described. This Journal, Feb. 1904, p. 100.

was unmistakable and is clearly shown in the curves plotted in fig. 1. The upper and lower curves, I and III, represent the decay of the activity of wires exposed in the open air on different days, while the curve between them, II, was obtained with a wire which had been exposed in a two-liter flask con-

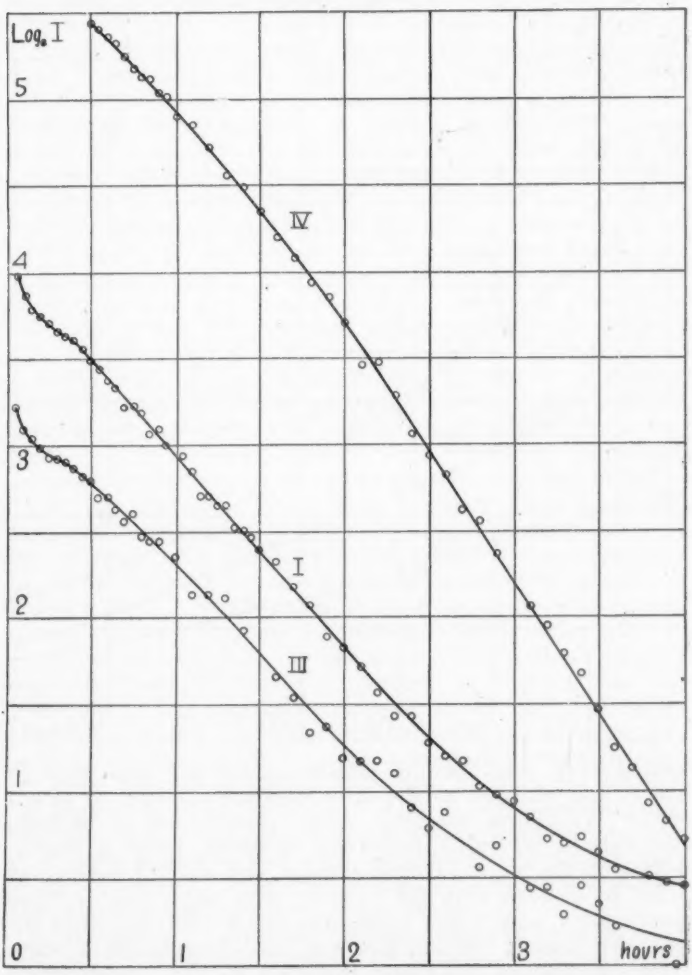
1



taining very weak radium emanation for the same time (3 hours), and charged to the same negative potential by means of the Wimshurst machine. The resemblance is obvious, especially in the initial rapid rate of decay, which is characteristic of the radium-excited activity, and which I have never failed to observe with the open-air wire when two or three observations were taken within the first ten minutes after the exposure ceased. When, however, the observations are carefully compared, it is evident that they do not entirely agree within the limits of experimental error; indeed a mere inspection of the curves in fig. 1 shows that, toward the end, the air wires were falling off at a slightly slower rate than the one exposed to radium emanation. It seemed probable that this

might be due to the presence of a small proportion of some form of activity decaying more slowly than that due to radium, and which would, therefore, show itself in a more and more

2



marked manner as time went on. Accordingly, wires 30 meters long were exposed in the same manner and observations carried on for four hours. The results of two such experiments are plotted in fig. 2, in which, for greater clearness, the nat-

ural logarithms of the ionization currents are plotted as ordinates, the time in hours being the abscissæ.* The curves I and III again represent the air wire, and curve IV a wire exposed to radium emanation, which is given for comparison. The existence of a slowly decaying activity is plainly shown by the curve between two and four hours. Twenty-four hours later, the wire was still appreciably radio-active, but the effect was too small to measure with accuracy; it was about one-fifth as active as at four hours.

In order to determine the rate of decay of this persistent activity, six lengths of wire were suspended in a wide zigzag between the second story windows of two buildings, the total length being 200 meters. They were allowed to sag from the horizontal by different amounts, so that their electrostatic fields should include as much of the surrounding air as possible. The small diameter of the wire made it possible to put this length into the testing vessel without difficulty. Nine hours after introducing it, the current through the cylinder was about six times that due to the "spontaneous ionization," of the air; and this, although small, was measurable with some degree of accuracy. Five observations were made at this time, and five more after an interval of 12 hours; combining them one by one, the following values of the coefficient of decay, λ, were obtained:

$$\begin{array}{r} 0{\cdot}069 \\ 0{\cdot}069 \\ 0{\cdot}066 \\ 0{\cdot}061 \\ 0{\cdot}073 \\ 0{\cdot}065 \\ \hline \lambda = 0{\cdot}067 \end{array}$$

The half-value time corresponding to this coefficient is $10\frac{1}{3}$ hours; and this is so near to the rate of decay of the excited activity due to thorium as to leave little doubt that the slowly decaying activity on the air wire is due to thorium. It is possible to increase the proportion of this to the more transient activity by prolonged exposure of the wire; for the radium-induced activity, an exposure of three hours is sufficient to practically reach the final equilibrium value, while the induced activity due to thorium will continue to increase for several days. By a twelve-hours exposure of a long wire, on a fine,

* On this diagram, radio-active substances which decay according to the same law will give parallel curves; if the law is exponential, the curve will be a straight line and the slope of the line will be equal to λ in the formula, $I = I_0 e^{-\lambda t}$. The zero of ordinates is a matter of indifference so that we may plot log I or (log I $\pm$ const.) as may be most convenient.

clear day, I have succeeded in collecting considerable quantities of this slowly decaying radio-activity. Eleven hours after the wire had been put into the testing cylinder, the current through the gas was 35 times that due to the spontaneous ionization and its gradual decay could be followed for several days. Observations extending over various intervals, from 6 hours to 27, showed that the decay was exponential and the average value of λ, from five determinations, was 0·0616, which indicates a decrease to half in 11·2 hours.

The observations upon the atmospheric activity can be accounted for fairly well, but not quite satisfactorily, by the assumption that it is entirely due to the excited activities of radium and thorium. In the following tables, the second column gives the calculated values of the ionization upon this assumption, the proportion of the two forms of activity being so chosen that the calculated and observed values shall agree at 1 hour and at 4 hours; for the present purpose, the decay of the thorium activity is assumed to be exponential (it is not actually so in the earlier stages) while the decay of the radium activity is found from Curve IV, fig. 2.* The third column gives the observed values for corresponding times, and the last column the differences between the calculated and observed values. The first table represents the experiments plotted in Curve I, fig. 2, the second, those plotted in Curve III.

CURVE I.

Assumed,

at 1 hour { Ra. activity = 17·0 ; Th. activity = 1·6

at 4 hours { Ra. activity = 0·244 ; Th. activity = 1·324

t (hours)	Calc.	Obs.	Diff.
1·0	18·6	18·6	0·00
1·5	11·1	10·8	+0·30
2·0	6·48	6·20	+0·28
2·5	3·81	3·69	+0·12
3·0	2·51	2·45	+0·06
3·5	1·89	1·84	+0·05
4·0	1·57	1·57	0·00

CURVE III.

Assumed,

at 1 hour { Ra. activity = 8·77 ; Th. activity = 1·23

at 4 hours { Ra. activity = 0·12 ; Th. activity = 1·02

t (hours)	Calc.	Obs.	Diff.
1·0	10·00	10·00	0·00
1·5	6·11	5·95	+0·16
2·0	3·73	3·53	+0·20
2·5	2·33	2·30	+0·03
3·0	1·67	1·67	0·00
3·5	1·32	1·32	0·00
4·0	1·14	1·14	0·00

*Up to 2·5 hours, this Curve IV, and other similar experiments which I have made, give a slightly different result from the empirical formula given by Curie and Danne (C. R., cxxxvi, p. 365, 1903) which is

$$I = I_0\left[ae^{-\frac{t}{\theta_1}} - (a-1)e^{-\frac{t}{\theta_2}}\right]$$

where $a = 4{\cdot}20$, $\theta_1 = 2420$ seconds, $\theta_2 = 1860$ seconds. This formula does not take into account the initial rapidly decaying activity due to radium. In the final, exponential part, my results are in close accord with those of Curie and Danne. The half-value time which they obtain is 27·9 minutes, while the value resulting from several experiments of my own is 27·7 minutes.

Although the differences are not large, they are apparently systematic and indicate that, between 1 and 2 hours, the air activity decays a little more rapidly than a combination of excited activities due to radium and thorium, while between 2 and 4 hours it decays more slowly. This cannot be due to the error committed in assuming the thorium activity to be decaying at its final rate; Rutherford has shown that, after a short exposure, thorium-excited activity at first increases so that a correction for this would be in the wrong direction. Another possible explanation of the discrepancy is that it may be due to an error in the determination of the curve for radium; a repetition of the determination, however, does not show any increase in the rate between 1 and 2 hours. If, therefore, we do not regard these differences as due to accidental errors (which seems unlikely in view of their apparent systematic character), they would seem to indicate the presence of a small proportion of some form of excited radio-activity decaying at a more rapid rate than that which the radium activity shows between 1 and 2 hours.* The present experiments are not sufficiently accurate to do more than indicate this as, to some extent, probable; but I am not without hope that it may be possible to go further in this direction by means of careful experiments especially directed to this end. The only other known induced activity, besides those due to radium and thorium, is that due to actinium. According to a recent determination by Debierne,† its decay is exponential and reaches half-value in 40 minutes. Its rate is, therefore, too slow to serve as an explanation of the discrepancy; but if a substance of more rapidly decaying activity is present, a small amount of actinium-excited activity is not impossible since there might be partial compensation between the two.

It is rather remarkable that, although the activity of the air wire is certainly due to a number of different forms of activity, decaying at different rates, the resultant effect between 0·5 and 2 hours is so nearly exponential, as indicated by the straightness of the lines in fig. 2. It is a further coincidence that, in this portion of the curve, the rate is so near the value found by Debierne for the excited activity due to actinium. The half-value time during this interval is, for Curve I, 38 minutes, for Curve III, 41 minutes. If the observations were not extended further, it would be a natural conclusion that the phenomenon was due to actinium emanation in the air. But the known presence of the thorium activity negatives the supposition that any considerable part of the effect can be due to

* Not necessarily more rapid than the final (half-value in 28 minutes) rate of the radium activity.

† Debierne, C. R., Feb. 5, 1904, p. 411.

actinium. The following tables will make this clear; they are like the two previously given except that, in the calculated column, it has been assumed that actinium and thorium activities are present instead of radium and thorium.

Curve I.

Assumed,

at 1 hour { Actin. activity = 17·6 ; Th. activity = 0·96

at 4 hours { Actin. activity = 0·78 ; Th. activity = 0·79

t hours.	Calc.	Obs.	Diff.
1·0	18·6	18·6	0·00
1·5	11·4	10·8	+0·60
2·0	7·11	6·20	+0·91
2·5	4·56	3·69	+0·87
3·0	3·04	2·45	+0·59
3·5	2·12	1·84	+0·28
4·0	1·57	1·57	0·00

Curve III.

Assumed,

at 1 hour { Actin. activity = 9·11 ; Th. activity = 0·89

at 4 hours { Actin. activity = 0·40 ; Th. activity = 0·74

t hours.	Calc.	Obs.	Diff.
1·0	10·00	10·00	0·00
1·5	6·27	5·95	+0·32
2·0	4·05	3·53	+0·52
2·5	2·72	2·30	+0·42
3·0	1·92	1·67	+0·25
3·5	1·43	1·32	+0·11
4·0	1·14	1·14	0·00

The differences are much larger than on the assumption of radium and thorium, and are quite beyond any possible experimental errors; and, to get even such an agreement, it is necessary to assume a smaller amount of thorium activity than the observations at later times than four hours will permit. Upon *a priori* grounds also, it is improbable that much of the effect can be due to actinium; the radium emanation is known to be present in the ground and decays so slowly (half-value in four days) that there is ample time for it to diffuse widely through the atmosphere; the actinium emanation, on the other hand, decays with great rapidity (half-value in four seconds),* and unless it were present in the ground in relatively enormous quantities, and not far from the surface, its effects in the open air could not predominate over those of the radium emanation. There is no reason to suppose that it does; any substitution of actinium for radium in the calculated values will cause them to depart more widely from the observed values. But, as previously remarked, if it should turn out that a small amount of a more rapidly decaying activity is present (as there is some reason to suspect), it is not impossible that some actinium activity may also be found. Mr. H. M. Dadourian, to whom I am indebted for assistance in many of the present experiments, is now engaged in an attempt to ascertain more definitely whether such an activity is present or not.

It will be observed that the general slope of Curve III is less rapid than that of Curve I, and that a considerably greater proportion of the thorium activity appears to be present. This, I think, may be accounted for from the known proper-

* Debierne, loc. cit.

ties of the radium and thorium emanations. The experiments plotted in I were made when the ground was hard frozen, and had been so (with occasional superficial thaws) for several months; III is the result of an exposure made a month later when the frost had entirely disappeared from the ground. The decay of the thorium emanation (half-value in one minute) is so rapid, compared with that of the radium emanation, that any delay in its liberation from the ground would considerably diminish the relative amount in the air. According to the accepted theory of radio-activity, due to J. J. Thomson and Rutherford, the disintegration of the gaseous emanation produces a solid material, responsible for the excited radio-activity, which, following Rutherford, we may call emanation X. . The particles of emanation X produced by the gas (of either kind) before it leaves the ground would never reach the upper air, since they would not diffuse like the molecules of a gas but would be deposited in the soil; on the other hand, those produced after the escape of the gas would settle very slowly, on account of their small size, and might be carried considerable distances by currents of air. The view that the smaller proportion of thorium activity is due to the frozen condition of the ground, is supported by two other experiments (incomplete and therefore not given in detail), one made while the ground was frozen and the other when it was not; in the latter case the decay was noticeably slower, indicating a larger proportion of the thorium activity. The smaller total activity observed in III might be thought to negative the above explanation; I think, however, that it was due to another cause. There was a very perceptible haze in the air on the day when this experiment was made and little wind; the day of the other experiment was exceptionally clear and a good breeze was blowing. The wind would bring more of the particles of the emanation X within the electric field of the wire, and the fact that they were not loaded with drops of water (or with very small ones) would cause them to move with a greater velocity along the lines of force and hence a greater number might be captured by the wire, even if the number in a cubic centimeter of the air were actually less. The only exposure of a wire which I have made on a clear, windy day since the ground thawed, was one of twelve hours, so that the result is not comparable directly with the three-hour exposure; moreover, the total activity was not observed, but only the thorium effect remaining after ten hours. Reducing this to its value four hours after exposure ceased, taking account of the difference in the lengths of the wires, and assuming that the relation between the thorium activity and the time of exposure is

$$I_t = I\left(1 - e^{-\lambda t}\right),$$

the value obtained indicates that about 75 per cent more thorium activity would have been deposited on wires of equal lengths, in the same time, on the clear day when the ground was not frozen than upon the clear day when it was.

A similar explanation may be given of the fact that the radio-activity of rain and snow, discovered by C. T. R. Wilson, decays at a different rate from that of the negatively charged wire. Wilson finds that the former falls to half-value in about 30 minutes;* and this is very near to the final rate of the radium-excited activity. If we assume that some of the drops in the rain clouds are condensed upon the positively charged particles of radium emanation X present in the air, the time occupied by the drops in falling, and in the collection and evaporation of the water, would prevent the earlier, non-exponential decay of this activity from being observed; all that would remain would be the final, regularly decaying product. The absence of a noticeable amount of thorium activity may be explained by the rapid decay of the thorium emanation; although the particles of thorium emanation X, present near the ground may sometimes be carried to considerable heights by the wind, the proportion of radium activity must steadily increase as we go upward, since, in the case of the radium activity, we have not only the particles blown up from near the ground but also those produced by the radium emanation *in situ*; the slow decay of this emanation allowing it to diffuse to much greater heights than the thorium emanation. It is to be expected that a negatively charged wire suspended several hundred feet above the ground would show a smaller proportion of thorium than one exposed near the earth's surface.

I have also looked for evidence of the presence of the thorium and actinium emanations in the soil but, up to the present, without definite results. It is, of course, useless for this purpose to draw air from the ground and introduce it into an electroscope or condenser, as in testing for the radium emanation, on account of the rapid decay of the thorium and actinium emanations. A galvanized sheet-iron pipe 15^{cm} in diameter and 2 meters long, with open bottom, was sunk in the ground and a negatively charged wire suspended in it. The top was closed and a gentle current of air was drawn through the cylinder (entering at the open bottom from the ground) by means of a filter pump. The wire did not acquire sufficient radio-activity to enable one to follow its decay for more than two hours, and, even during this time, the ionization produced in the cylinder

* Proc. Camb. Phil. Soc., xii, p. 17 (1902).

was too small for accurate observations to be made. The rate appeared to be somewhat slower than that of the excited activity due to radium but no great confidence can be placed in the result. It is likely that a larger cavity in the ground would give more definite results but I have not yet been able to try this.

Conclusions.

1. The radio-activity aequired by a negatively charged wire exposed in the open air (at least as observed in New Haven) is mainly, if not wholly, due to the excited activities of radium and thorium. With a three-hour exposure, 3 to 5 per cent of the total initial effect is due to the thorium activity, the proportion depending apparently upon the greater or less ease with which the emanations escape from the soil. With a twelve-hour exposure the thorium activity is sometimes 15 per cent of the whole, and with a long wire, its decay may be followed for several days. There is some evidence that a small quantity of a more rapidly decaying activity is present in addition, but these experiments do not definitely establish this.

2. The radio-activity of rain and snow is probably due to radium-excited activity, the absence of the thorium effect being accounted for by the fact that the rapid decay of the thorium emanation prevents its reaching, in appreciable quantities, the height at which the rain-drops are formed.

Sheffield Scientific School of Yale University, April, 1904.

ART. II. — *Studies in the Cyperaceæ;* by THEO. HOLM. XXII. The Cyperaceæ of the Chilliwack Valley, British Columbia (between lat. 49° and lat. 49° 10′; and long. 121° 25′ and long. 122°). (With figures in the text drawn from nature by the author.)

THROUGH the courtesy of Mr. James M. Macoun, the writer has had an opportunity of examining a collection of *Cyperaceæ* which was made by him in the Chilliwack Valley during the summer of 1901, and upon which we take pleasure in presenting the following report. With the exception of *Scirpus Macounii* most of the others are old and well known species, but nevertheless of some interest from a geographical point of view, besides that, several of these represent types that have not hitherto been clearly accounted for, viz: *Carex scirpoidea*, *C. vulgaris* var. *lipocarpa*, *C. spectabilis*, etc.

I. SYNOPSIS OF THE SPECIES.

Carex.

VIGNEA.

Brachystachyæ nob.

Carex canescens L. Boggy spots, the lake (No. 26,651).

C. vitilis Fr. Swamps, the lake (No. 26,652) and among moss on rocks, 3,500 ft. alt. (No. 26,659).

C. arcta Boott. By marshes, Sumas Lake (No. 26,653).

Neurochlænæ nob.

C. nardina Fr. Crevices of rocks, 6,500 ft. alt., Tami Hy Mountain (No. 33,689).

Argyranthæ nob.

C. Deweyana Schw. Woods, the river (No. 26,644).

C. Deweyana Schw. var. *Bolanderi* Boott. Grassy slopes, 2,000 ft. alt. (No. 26,655); banks of streams, the river (No. 26,654); stumps by streams, the lake (No. 26,643).

Astrostachyæ nob.

C. interior Bail. Boggy marsh, east of the lake (No. 26,658).

C. læviculmis Meinshaus. Swampy places, the river (No. 26,657) and boggy spots, the lake (No. 26,656).

Stenorhynchæ nob.

C. stipata Muehl. Along ditches, near town (No. 33,736).

Phænocarpæ nob.

C. teretiuscula Good. var. *ramosa* Boott. Marshes east of the lake (No. 33,743).

Athrostachyæ nob.

C. Crawfordii Fern. By ditches (No. 26,649).

C. festiva Dew. By rivulets, 5,500 ft. alt., Tami Hy Mt. (No. 26,646) and along the river at 4,000 ft. alt. (No. 26,645). (Fig. 1.)

C. festiva Dew. var. Gravel bars, the river (Nos. 26,647–48). (Fig. 5.)

Pterocarpæ nob.

C. Bebbii Olney. In mud by the river (No. 26,650).

CARICES GENUINÆ.

Melananthæ Drej.

C. Mertensii Prescott. By springs, the river (No. 33,670) and by rivulets, the lake (Nos. 33,671–72).

C. spectabilis Dew. Near melting snow, 5,000 ft. alt., Tami Hy Mt. (No. 33,659). (Fig. A.)

Microrhynchæ Drej.

C. vulgaris Fr. var. *lipocarpa* nob. By a rivulet, 4,000 ft. alt., the lake (No. 33,631) and by a pond, Tami Hy Mt. (No. 33,630).

C. dives nob. Marshes, the lake (No. 33,753).

Lejochlænæ nob.

C. polytrichoides Muehl. Marshes, the lake (No. 33,660).

C. Hendersoni Bail. In thickets of *Alnus* and *Acer glabrum*, alluvial soil along the river (No. 33,657).

Athrochlænæ nob.

C. nigricans Mey. Near melting snow, 5,000 ft. alt., Tami Hy Mt. (No. 33,705).

Stenocarpæ nob.

C. ablata Bail. Damp Banks, 4,000 ft. alt., the lake (No. 33,715).

Sphæridiophoræ Drej.

C. scirpoidea Michx. var. *stenochlæna* nob. By a rivulet, 4,000 ft. alt., the lake (No. 33,728). (Fig. 7.)

C. Rossii Boott. Rocky woods, the lake (No. 33,634) and on a snow-slide (No. 33,747).

Physocarpæ Drej.

C. utriculata Boott. Marshes east of the lake (No. 33,642).

Scirpeæ

Eleocharis ovata R. Br. (No. 34,772).
E. palustris R. Br. (No. 34,773).
Scirpus cæspitosus L. Alt. 3,500 ft. (No. 34,770).
S. Macounii nob. (No. 34,771). (Fig. 9.)
Eriophorum gracile Koch. (No. 34,769).
E. angustifolium Roth. Alt. 5,000 ft. (No. 34,768).

II. Notes on New or Little Known Species.

Carex vitilis Fries.

Several authors have generally confounded this well defined species with *C. brunnescens* (Pers.) Poir., known also as *C. Persoonii Sieber*, and *C. Gebhardi* Hoppe, furnishing a diagnosis which may be well suitable to both, but far from correct as to either. Both have been very clearly defined by Fries himself,* by Koch,† Blytt‡ and various others, and the distinctive characters may be drawn up as follows: The inflorescence of *C. vitilis* is composed of about five, remote, subglobose spikes with yellowish, spreading perigynia of which the beak is quite distinct and almost entire. In *C. Persoonii*, on the other hand, the spikes are oblong, brownish, and the perigynia are not spreading, but erect with a beak slit in its entire length on the outer, convex face. Both species are closely related to the frequent *C. canescens* L. but from which they are readily distinguished, however, by their color, as indicated, their slender culms and narrow leaves, and especially by the structure and position of the perigynium.

If this distinction be sufficient for considering *C. vitilis* and *C. Persoonii* valid species, a view which the writer feels most inclined to uphold, the latter, *C. Persoonii*, evidently does not occur on this continent, judging from the fact that we have never observed it in any of the large collections so far examined.

Carex festiva Dew.

Very few *Vigneæ* exhibit such pronounced ability to vary as is possessed by this species, and the plasticity becomes especially noticeable when we compare individuals from various stations from East to West: from Scandinavia to the Pacific slope, rather than from North to South or at different elevations in the mountains. For strange as it seems, several of the most characteristic deviations from the type often occur at the same altitude, from the subalpine to the high alpine regions, besides

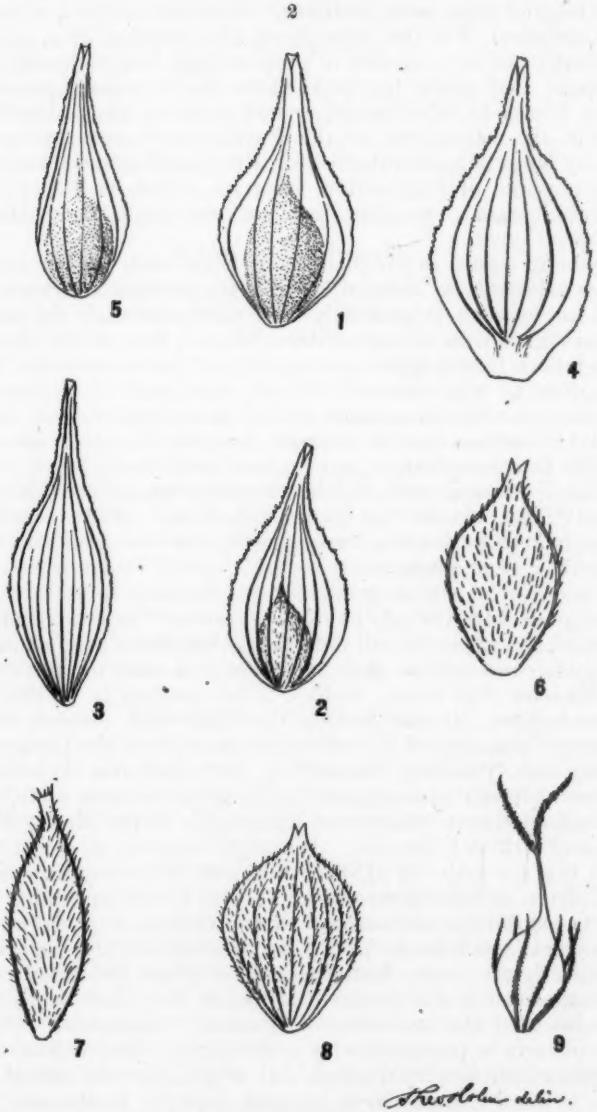
* Fries, Elias: Novit. Floræ Suecicæ mantissæ, iii, p. 137.
Same: Summa veget. Scand., 1846, p. 223.
Same: Botan. Notiser, Lund., 1844, p. 23.
† Koch: Synopsis Floræ Germ. et Helvet., ii, 1857, p. 655.
‡ Blytt, M. N.: Norges Flora., i, 1861, p. 199.

that none of these seem restricted to certain northern or southern latitudes. On the other hand, the variation of *C. festiva* appears to be well marked in proportion to longitude, and it so happens that while the type seems to be equally dispersed from Alaska to Scandinavia, certain varieties are restricted to within the boundaries of the Pacific slope eastward to the Rocky Mountains, in other words, the species affords an excellent example of longitudinal variation, which we believe is a feature common to plants of southern origin in contrast to northern types.

Now in regard to the plant from Chilliwack Valley, and we refer especially to Nos. 26,645 and 46, this seems to represent the species as it is generally recognized, although the perigynium (fig. 1) is faintly several-nerved, and it must be borne in mind that Dewey makes no mention of such nervation in his diagnosis of the species:* "Spicis distigmaticis androgynis, superne pistilliferis subsenis ovatis in capitulum dense aggregatis; fructibus ovatis oblongis rostratis in apice serrulatis bifidis convexo-planis, squama ovata acutiuscula longioribus."

The specimens upon which the species was established came from "Bear Lake and the Rocky Mountains." However, all subsequent authors describe the perigynium as nerved on both faces, faintly or even prominently so, and Boott,†" who had authentic material at his disposal, did not hesitate to refer similar specimens with the perigynium "nervose" to this species of Dewey. And, so far, all individuals that have been examined and described exhibit such nervation to a more or less extent, a character that seems, besides, to be common to all the varieties known. It may be that the Chilliwack plant is nearer the type than any of the others on account of the perigynium being merely faintly few-nerved, but otherwise it is hardly different from the one figured as No. 2 on the same plate, taken from a specimen collected at Kananaskis in the Rocky Mountains of British Columbia. We might here call attention to the fact that the majority of specimens, generally recognized as typical, from this continent as well as from Greenland and Scandinavia exhibit the same nervation and outline of perigynium as the plant from Kananaskis (fig. 2). The habit of these specimens is exactly the same, furthermore the shape and color of the inflorescence is also similar. If we, on the other hand, examine some of the varieties, for instance "*decumbens*" (fig. 4), we observe a perigynium of much larger proportions and a habit, which is very distinct, and which, to some extent, may call to mind that of *Carex incurva Lightf.* In the var. *Haydeniana* (fig. 3) the perigynium shows the same nervation,

* This Journal, vol. xxix, 1836, p. 246.
† Illustr. of the genus *Carex*, vol. 1, p. 26.



but the outline is very different, the body being very narrow and the beak relatively longer than in the typical plant, besides that the color of the spikes is very dark, almost black. Never-

theless, none of these varieties seem sufficiently characteristic for being considered as specifically distinct, inasmuch as many intergradating forms have been observed between these and the one which we consider typical.

There is, still, another *Carex* from the Chilliwack Valley, which we are most inclined to refer to this same species, although its very slender culms and leaves, besides the conspicuously spreading perigynia, make it somewhat anomalous as *C. festiva*. Specimens of this plant (No. 26,647–48) were labeled *C. illota* Bailey by Mr. Macoun, and from their habit they are not unlike this species, which, however, is identical with Kunth's *C. Bonplandii* var. *angustifolia*. An examination of the perigynium (fig. 5) proved, however, that this does not show the structure of that of *C. Bonplandii*, but rather that of *C. festiva*, hence we prefer to enumerate it, at least "ad interim," as a variety of the latter.

Carex spectabilis Dew. (fig. A, p. 18.)

The original diagnosis* reads as follows: "Culm 8 to 12 inches high, erect, smooth, striate; leaves sheating, flat and smooth, upper ones about equalling the culms; bracts long and leafy; staminate spike single, erect, cylindric and oblong, with oblong obtusish scales; stigmas 3; pistillate spikes 2 to 3, ovate, cylindric, erect, remotish, pedunculate, and the lowest long-pedunculate, sheaths short; fruit ovate, obtuse nerved, scarcely rostrate, orifice two-lobed; pistillate scale oblong, lanceolate, short mucronate, all reddish brown, and a little longer than the fruit. Found in the Arctic regions."

Carex spectabilis in several respects is suggestive of *C. macrochæta* Mey., but differs constantly from this by its merely mucronate squamæ, the cylindrical and dense-flowered spikes, the two-lobed or simply emarginate orifice of the perigynium (figs. a, b and c), of which only three nerves are visible on the outer face. In *C. macrochæta* the scales are aristate, the mid-vein being very much extended beyond the apex of the scale, the spikes are relatively shorter and lax-flowered; furthermore, the perigynium is quite prominently several-nerved and the orifice entire (fig. d) and constantly so, judging from the numerous specimens which we have examined. But common to both are the aphyllopodic culms and distinctly pedunculate pistillate spikes, which, however, are often drooping in *C. macrochæta*, but merely spreading or erect in *C. spectabilis*. As to the color of the foliage, it appears as if the leaves and perigynia are deeper green in the latter.

* This Journal, vol. xxix, 1836, p. 248.

The systematic position of *C. macrochæta* seems most naturally to be among the *Aeorastachyæ*, but in regard to the other species, certain analogies exist between this and *C. atrata*, *C. Mertensii* and their allies, thus we have placed *C. spectabi-*

lis as the last member of the *Melananthæ*, showing transition to the former "grex" through *C. macrochæta*. The geographical distribution of *C. spectabilis* extends from the Chilliwack Valley south to California, but the species is evidently quite rare.

Carex vulgaris Fr. var. *lipocarpa* nob.

Most of the material of *C. vulgaris* secured from the Northwest belongs to this variety, and it is this plant which by recent American Caricographers has been identified as Boott's *C. decidua*. Mr. C. B. Clarke has called our attention to this mistake, and we owe to him the important information, that even if Boott at one time considered both of these identical, he, later on, corrected the determination in regard to the West American plant, and reserved the specific name *decidua* to the South American exclusively.

The diagnosis of *C. decidua* was published in Transacts. Linn. Soc. (vol. xx, 1845, p. 119), and the following points may be quoted as sufficient for distinguishing the species from varieties of *C. vulgaris:* "spicis 4–7 erectis; suprema mascula vel androgyna basi vel apice et basi mascula—perigyniis denticulato—serratis." It is no doubt a near ally of *C. vulgaris*, and perhaps more especially so of the variety *lipocarpa*, but even if the perigynia and the scales are deciduous in both, the characters enumerated above are not to be observed in this particular form of *C. vulgaris*.

Carex dives nob.

No. 33,753 of this collection was identified by Mr. Macoun as *C. variabilis* Bail. var. *elatior* Bail., but it differs in several essential points from this variety and can not be referred to *C. variabilis*. Habitually it is more like *C. Sitchensis* Presc., but the spikes are more numerous, more dense-flowered, the squamæ lack the characteristic spot at the apex, the perigynium is broader, prominently granular and often spinulose along the upper margins, hence we have identified the species as our *C. dives*, established upon a plant from Oregon, collected several years ago by Professor Henderson. The species is closely allied to *C. Sitchensis*, and may be placed near this and *C. acuta* of the *Microrhynchæ*.

Carex Hendersonii Bail.

This represents the Western and especially the Northwestern type of the higher developed *Lejochlænæ* of this continent, the others showing a decided Eastern distribution, for instance *C. laxiflora*, *C. plantaginea*, *C. digitalis*, etc. But among the lower forms, among those which we have enume-

rated as "hebetatæ," are some, which are also characteristic of the Western States, e. g., *C. Geyeri* and *C. multicaulis*, while *C. polytrichoides* is rare in that part of the continent, but abundant in the East, on the Atlantic slope.

Carex scirpoidea Michx.

The original diagnosis reads: "C. planifolia, dioica," spica unica, imbricato-cylindrica: capsulis dense pubescentibus, Hab. ad sinum Hudsonis."*

The first specimens known were thus monostachyous, but since then the species has been observed as being, and not very uncommonly so, distachyous: with a small, lateral spike, staminate in the staminate plant, pistillate in the pistillate, developed in the axil of a bract, which is always noticeable in a short distance below the terminal spike, as already mentioned by Drejer, who observed this peculiarity in Greenland specimens. The geographical distribution has been widely extended from Hudson Bay throughout the continent towards the Atlantic and Pacific slope, as far south as Colorado and California, besides that the species has been recorded from Greenland and even from the mountains of northern Norway, where it, however, seems to be very rare. It is very natural that a species, so widely dispersed, exhibits some variation, and as indicated in the enumeration of the species the Chilliwack plant deviates to some extent from the typical, the one from Hudson Bay, which is, also, the most commonly met with. We have, furthermore, noticed some peculiarities in the Californian plant, which seem to warrant the proposition of some varieties. The variation, however, seems confined to the structure of the utricle rather than to the relative size of the plant, its robustness, the outline of the spike, etc., characters that seem too variable to be depended upon in any species of the genus. The Chilliwack plant may be described as follows:

var. *stenochlæna* nob.

A very tall and slender plant with the pistillate spike clavate, loose flowered, especially at the base, the perigynium (fig. 7) longer and much narrower than in the type, spreading, very densely pubescent, with the orifice of the beak entire, ciliate; stigmata 3. Also collected in Alaska: Juneau and by Yes Bay.

var. *gigas* nob. (fig. 8).

Spikes mostly 2, very robust and dense-flowered; the number of bracts sometimes 3 (2 empty); perigynium broader than in the type, loosely pubescent and distinctly many-nerved, orifice of the beak as in the type, bidentate; stigmata 2 or 3,

* Michaux: Flora boreali-Americana, ii, 171.

the style not exserted. Only known from Siskyiou County, California: Mt. Eddy.*

Scirpus Macounii sp. n. (fig. 9).

Perennial with ascending shoots, the leaf-sheaths not fibrillose; basal leaves much shorter than the culm, flat, about 1^{cm} wide, the midrib distinct, very scabrous below, glabrous above, light green; cauline leaves with long sheaths; culm erect, triangular scabrous, leafy to about the middle, one meter in height, phyllopodic; inflorescence umbellate, decompound, the primary rays scabrous, from 1 to 7^{cm} in length subtended by long, foliaceous involucral bracts and small, tubular prophylla with or without a short setiform blade; secondary rays many but much shorter, only 1 to 3^{cm} in length, subtended by scale-like leaves and minute prophylla; spikes 3 to 6 together, sessile, cylindric, about half a centimeter in length; scales greenish brown, lanceolate, acuminate, the midrib stout and extended into a short mucro; setæ 6, straight, a little longer than the caryopsis, downwardly barbed to near the base; stamens 2, seldom 3; stigmata 2 or 3; caryopsis light brown, roundish in outline, compressed triangular in cross-section.

Evidently a near ally of *S. sylvaticus*, but in this the scales are obovate-oblong, slightly emarginate with a short mucro from the extended midrib, the stamens are only 2 in number, the setæ 4 and the stigmata nearly always 2, besides that the spikes are shorter and more oval.

III. The Geographical Distribution.

The *Cyperaceæ* of the Chilliwack Valley represent certain types of wide geographical range, some of which are arctic: *Carex nardina*, *festiva*, *scirpoidea*, *Eriophorum gracile* and *Scirpus cæspitosus*, while *Carex canescens* and *Eriophorum angustifolium* are even circumpolar. Some others are confined to this continent, but extend as far east as the Atlantic slope, for instance *Carex Bebbii*, *interior*, *Crawfordii*, *Deweyana*, *arcta*, *stipata*, *teretiuscula* and *polytrichoides*, while *C. læviculmis*, *Mertensii*, *spectabilis*, *vulgaris* var. *lipocarpa*, *dives*, *Hendersonii*, *nigricans*, *ablata* and *Rossii* are mostly western species, sometimes, however, extending eastward to the Rocky Mountains. *Eleocharis palustris* is cosmopolitan, and *E. ovata* is known from Middle Europe, Caucasus and Dahuria, besides from Australia.

Moreover, some of these species occur as alpine farther south,

* *C. pseudoscirpoidea* Rydberg has been described in the Flora of Montana (p. 78) as a segregate from *C. scirpoidea* Michx., but we find none of the characters sufficient for segregating the Montana plant from the type; moreover, the description is incorrect, for instance the perigynium is said to be "densely hirsute" instead of merely "pubescent," etc., besides that the name "Greek-Latin-Greek" is not admissible.

in Colorado: *Carex nardina* and *festiva*, while *C. Rossii*, *nigricans* and *scirpoidea* (the typical) are merely subalpine.

When we consider the *Cyperaceæ* of the Chilliwack Valley by themselves, they offer a strange commingling of types not only in regard to their distribution elsewhere, but, also, in respect to the types they represent. No doubt the flora of the valley has been influenced, and to a great extent, by the receding ice during the glacial epoch, when a number of plant-species moved north by way of the Rocky Mountains, but there is, also, some evidence of other species having reached this place in a much later period, for instance the eastern species.

It would be interesting to know how the geographical distribution compares with the other orders, and quite especially with those that contain types of the arctic or at least of the northern Flora, such as the *Saxifragaceæ*, *Ranunculaceæ*, *Juncaceæ* and *Gramineæ*. And in regard to the types, as we have seen these represented by the *Cyperaceæ*, it is somewhat strange to see so many *Vigneæ* in proportion to *Carices genuinæ* in a corner of the continent, where the latter usually appear to be predominating in species as well as in individuals; for the latter are really poorly represented, when compared with those of the Alaskan coast and Oregon. This seems the more remarkable when we notice that the *Scirpeæ* of the valley are the same, almost, as those of Alaska and vicinity.

As far as concerns the *Cyperaceæ*, the valley seems to have been a meeting-place of a number of species from remote localities and of remarkably specialized types, so utterly unlike each other. The magnificent collections and carefully drawn observations will, no doubt, enable Mr. Macoun to further illustrate the character, the composition and origin of this interesting vegetation.

EXPLANATION OF FIGURE I.

FIGURE 1.—Perigynium of *Carex festiva* (No. 26,646) Chilliwack Valley; magnified.
FIGURE 2.—Perigynium of *Carex festiva* from Kananaskis, Rocky Mts., B. C.
FIGURE 3.—Perigynium of same var. *Haydeniana* from Mt. Massive, Colorado.
FIGURE 4.—Perigynium of same var. *decumbens* from Pagosa peak, Colorado.
FIGURE 5.—Perigynium of same var. (No. 26,648) from Chilliwack Valley.
FIGURE 6.—Perigynium of *C. scirpoidea* (typical) from Montana.
FIGURE 7.—Perigynium of *C. scirpoidea* var. *stenochlæna* from Chilliwack Valley.
FIGURE 8.—Perigynium of *C. scirpoidea* var. *gigas* from Mt. Eddy, California.
FIGURE 9.—Caryopsis and setæ of *Scirpus Macounii* sp. n.

FIGURE II.

Carex spectabilis from Chilliwack Valley; natural size.

FIGURE *a*.—Perigynium of same, magnified.
FIGURE *b*.—Perigynium of same from Nevada County, California.
FIGURE *c*.—Perigynium of same from Kicking Horse Lake, B. C.
FIGURE *d*.—Perigynium of *C. macrochæta* from Alaska.

Art. III. — *Note on a New Permian Xiphosuran from Kansas;* by Charles E. Beecher.*

Through the courtesy of Mr. J. W. Beede, of Indiana University, the writer has had an opportunity to examine a portion of the cephalothorax of a large Xiphosuran from the Permian of Kansas. It apparently belongs to the genus *Prestwichia* and it is chiefly interesting, aside from its large size, on account of its coming from a higher horizon than any other American species yet known.

1

Figure 1.—*Prestwichia signata* restored and of natural size. The smooth lateral or genal regions are the parts restored.

In the March number of the American Geologist for 1902, the writer described a species of *Prestwichia* from the Chemung (Devonian) of Pennsylvania, which carried the geological distribution of the genus from the Coal Measures to the Upper Devonian. The present species extends its range in the other direction as far as the lower Permian. The Carboniferous forms of *Prestwichia* in general show very little evidence of the segmental nature of the cephalothorax, and it was of considerable interest to describe in the Chemung species a series of nodes on each side of the glabellar region corresponding, it was believed, to five of the six pairs of appendages on the ventral side. The new Permian form also exhibits a similar series of appendicular lobes on each side of the axis, which agree in

* Among the papers of the late Professor Beecher was found the manuscript of this article as here printed. The manuscript was compared with the cast of the fossil and found to be complete as far as the very imperfect but interesting specimen will permit.—Charles Schuchert.

position and form with the earlier species. It is also possible to detect an additional anterior pair, making the full number of six altogether.

Prestwichia signata, sp. nov. (figure 1).

A diagnosis of the species is necessarily quite incomplete, owing to the fact that thus far only a portion of the internal mold of a single cephalothorax has been discovered. It is believed, however, that the characters preserved will readily serve to identify the species, which is geologically quite important.

Cephalothorax large, depressed, convex, flattened on the dorsal side between the eyes, slightly arched in a longitudinal direction. The glabellar region is marked by a subconical elevation, angular along the median line, and terminating in front by a small, round ocellar node, distant from the anterior margin about one-sixth of the estimated length of the cephalothorax. Extending from the posterior margin of the cephalothorax are two low subangular ridges starting at points from the median line equal to the basal diameter of the glabellar cone, passing forward and curving slightly outward to the eyes, thence turning a little toward the axis and merging into the general contour before reaching the anterior end of the cone. The space thus enclosed on each side is occupied by five low rounded nodes, of which the posterior one is somewhat the larger and obliquely pointed behind. Just at the apex of the cone, and behind the ocellar node, is a pair of small transverse nodes, thus making six on each side. The second and third of each series are faintly delimited, while the fourth, fifth, and sixth are very clearly shown. The glabellar axis also shows extremely faint annulations corresponding to the lateral lobes. Opposite the third pair of lobes are the reniform or crescentic eyes, which are large and prominent for the genus. Two minute spots on each side of the small anterior median lobe, and distant from each other about 1·5^{mm}, indicate the ocelli.

The surface of the specimen represents a mold of the inner surface of the test, and is covered with a plexus of very slender anastomosing vascular furrows and ridges, much like those in the modern *Limulus*.

The cephalothorax as preserved has a length of 45^{mm}. The glabellar cone measures 33^{mm} in length and 18^{mm} across at the base. The outer edge of the eyes is about 20^{mm} distant from the median line and measures fully 5^{mm} in anteroposterior diameter.

Genal regions, abdomen, and telson unknown.

Horizon and Locality.—In the Fort Riley limestone of the lower Permian, three miles west of Stockdale, Kansas. The plastotype is in the Yale University Museum.

Laboratory of Paleontology, Yale University Museum,
New Haven, Connecticut, December 1, 1903.

ART. IV.—*Kunzite and its Unique Properties;* by CHARLES BASKERVILLE and GEORGE F. KUNZ.

IN a recent investigation* made by us on the behavior of a large number of minerals and gems with various forms of radiant energy, including the emanations, as well as on the production of luminescence in some cases by other physical means, the new variety of spodumene, designated kunzite, was found to be peculiarly sensitive, and to exhibit some remarkable properties.

In general, as shown by these investigations, the gem-minerals were little affected by ultra-violet rays: but three species exhibited a high degree of responsiveness to these and to all forms of radio-activity, so far experimented with. These minerals were diamonds of certain kinds; willemite (zinc orthosilicate), which in some cases has been used as a gem-stone, and kunzite. The behavior of the last, as noted in various experiments, is unique and will be briefly described here by itself.

1. *Attrition and heat.*—Kunzite does not become luminous by attrition, or rubbing. Several specimens were held on a revolving buff cloth making 3000 revolutions per minute, so hot as to be almost unbearable to the hand, and still it failed to become luminous. Wollastonite, willemite and pectolite are, however, very tribo-luminescent.

As to luminescence induced by heat alone, it was found that kunzite does possess the property of thermo-luminescence to some extent, with an orange tint and at a low degree of heat.

2. *Electricity.* — The mineral assumes a static charge of electricity, like topaz, when rubbed with a woolen cloth. On exposing kunzite crystals of different sizes to the passage of an oscillating current obtained from large Helmholtz machines, the entire crystal glowed an orange-pink, temporarily losing the lilac color. A well-defined, brilliant line of light appeared through the center, apparently in the path of the current. On discontinuing the current, the crystal gave the appearance of a glowing coal. It was not hot, however, and the phosphorescence lasted for forty-five minutes.

Three large crystals, weighing 200, 300 and 400 grams each, were attached to copper wires so that the current passed in one instance from below up, and from the other upwards across the crystal—first across the prism, then parallel with the prism. In each instance the crystals became distinctively luminous, a pale orange-pink, and between the two wires a bright almost

* Science, N. S., xviii, 769, 1903.

transparent line passed from one wire to the other; in reality, as if the two elongated cones crossed each other, the line of the path being transparent at the sides, whereas the rest of the crystals appeared translucent. After the exposure of two minutes, they were laid upon photographic plates and in five minutes produced a fine auto-print, herewith shown. The crystals continued to glow for forty-five minutes.

1 2

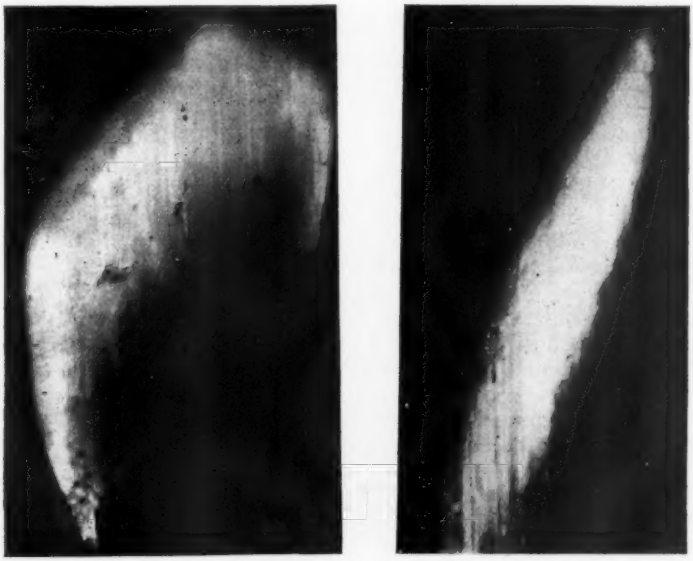


FIGURE 1.—Self-print made by the exposure of crystal of kunzite to the Roentgen rays for five minutes. Note the frond-like emanations at the ends of the crystal.—Reduced one-half.

FIGURE 2.—Auto-print of crystal of kunzite luminescence induced by an oscillating current obtained from a Helmholtz machine.—Reduced one-half.

When a cut gem is suspended between the two poles, it becomes an intense orange-pink color, glowing with wonderful brilliancy. The discharge seemed as if it would tear the gem asunder, although actually it was unaffected.

3. *Ultra-violet rays.*—These invisible rays, produced by sparking a high voltage current between iron terminals, caused kunzite, white, pink or lilac, to phosphoresce for some minutes. The white responded most readily.

4. *Roentgen, or X-rays.*—All forms of kunzite become

strongly phosphorescent under these rays. An exposure of half a minute caused three cut gems to glow first a golden-pink, and then white for ten minutes. The glow was visible through two thicknesses of white paper, which was held over it. A large crystal excited for five minutes afterward affected a sensitive photographic plate.* Another crystal, exposed for ten minutes, was laid for five minutes on a sensitive plate.† The resulting auto-photograph was clear and distinct, but presented a very curious aspect not seen by the eye—as of a misty or feathery outflow from the side and termination of the crystal, suggesting an actual picture of the invisible lines of force. The other varieties of spodumene, mineral material and cut gems, failed to show this property. We are not yet in a position to offer a satisfactory explanation of the above.

Whereas kunzite is so responsive and fluorescent and so beautiful upon exposure to the X-rays, it is, however, like all silicates, opaque to the ray itself. Four crystals weighing 100, 200 and 400 grams each, were exposed to the Roentgen ray for two minutes. They became first a beautiful rose-orange, then assumed a white phosphorescence, and at the end of forty-five minutes there was still a faint residual glow. Two minutes exposure to the X-ray caused them to print a perfect auto-type (herewith shown, fig. 2). The glow in all instances showed first a rose-orange color, then a pale pink, finally resolving into a white fluorescence; the auto-print shows the feathery outlines of light or energy thrown out by the crystal.

5. *Conduct with radium preparations.*—Exposed for a few minutes to radium bromide with a radio-active strength of 300,000 (uranium being taken as unity), the mineral becomes wonderfully phosphorescent, the glow continuing persistently after the removal of the source of excitation. The bromide was confined in glass. Six hundred grams of kunzite crystals were thus excited with 127 milligrams of the radium bromide in five minutes. The effect is not produced instantaneously but is cumulative, and after a few moments exposure the mineral begins to glow, and its phosphorescence is pronounced after the removal of the radio-active body. The luminosity continued in the dark for some little time after the radium was taken away. No other varieties of spodumene examined, including hiddenite, gave like results. In this respect, as with the Roentgen rays, the kunzite variety stands by itself.

When pulverized kunzite is mixed with radium-barium chloride of 240 activity or carbonate of lower activity, the mixed powder becomes luminous and apparently remains so permanently; i. e., in several months no loss has been observed.

* Science, N. S., xviii, 303, 1903.

† This was made by Dr. H. G. Piffard of New York City.

The same is the case if pulverized wollastonite or pectolite be used instead of the kunzite. When either of these mixtures is put in a Bologna flask and laid on a heated metal plate (less than red-hot), the powder becomes incandescent and remains so for a long time after removal.

These three minerals phosphoresce by heat alone, as was mentioned above in regard to kunzite. Perhaps this luminosity of the mixed powders at the ordinary temperature may be accounted for in part by the evolution of heat* on the part of the radium compounds, but there are experimental reasons which cause us to reject such explanation for the total effect.

The *emanation* of radium, the α-rays, according to Rutherford† are condensed at a temperature of $-130°$ to $-140°$ C. The emanations were driven from radium chloride by heat and condensed with liquid air on a number of kunzite crystals, according to a method which will be described by one of us (B) and Lockhart in another paper, and *no phosphorescence observed.* Consequently *kunzite responds only to the* γ*-rays*, which are believed to be virtually Roentgen rays.

6. *Actinium.*—A sample of the still more rare and novel substance discoverd by Professor Debierne‡ and received from him through the courtesy of Professor Curie, was also tried as to its action upon kunzite and some other minerals. The actinium oxide, with an activity of 10,000 according to the uranium standard, gave off profuse emanations and affected diamonds, kunzite and willemite in a manner similar to the radium salts, with quite as much after-continuance. However, we have not tried the condensation of these emanations upon the minerals by refrigeration.

The peculiar properties of the kunzite variety of spodumene, which have been enumerated, have not been observed in any other of the gem or gem-minerals that we have examined. It is barely possible that the small amount of manganese may have much to do with it, but from our present knowledge basing a chemical explanation thereon is idle.

* P. Curie and Laborde, Comptes Rend., cxxxvi, 673.
† Phil. Mag., v, 561. ‡ Compt. Rend., cxxix, 593.

ART. V.—*Analysis of Kunzite;* by R. O. E. DAVIS.

AT the request of Professor Charles Baskerville, Director of the Chemical Laboratory, I undertook the chemical analysis of kunzite, the new and beautiful variety of spodumene, described by Kunz and himself.* The methods used were those given in Hillebrand's excellent "Principles of Rock Analysis" † and need not be re-stated here.

A selected, clean, deep lilac-colored crystal, quite free from flaws, was ground to an impalpable powder and used in the analytical work. Following are the figures obtained:

	Percent.
SiO_2	64·05
Al_2O_3	27·30
NiO	0·06
MnO	0·11
ZnO	0·44
CaO	0·80
MgO	none
K_2O	0·06
Na_2O	0·30
Li_2O	6·88
Loss on ignition	0·15
Total	100·15

No chromium, vanadium, titanium, iron, strontium, barium, thorium, zirconium or phosphorus was found. On account of the unique properties possessed by the mineral the other rare earths were looked for. Dr. W. J. Humphreys, of the Rouss Physical Laboratory of the University of Virginia, kindly photographed the arc spectrum obtained from the material which had been freed from silicon and lithium. He reported none of the characteristic lines of cerium and yttrium groups present. The material lost its pink color on ignition.

University of North Carolina.

* See the preceding paper; also Science, xviii, 303 and 769, 1903.

† Bulletin of the U. S. Geological Survey, No. 176.

ART. VI.—*The Occurrence of Celestite near Syracuse, N. Y., and its Relation to the Vermicular Limestones of the Salina Epoch;** by EDWARD H. KRAUS.

LAST summer, while conducting a field excursion with a class in geology from the Summer School of Syracuse University along the new Jamesville branch of the Syracuse and Suburban R. R., the mineral celestite was noticed. Although Dana† and Whitlock‡ mention Syracuse as a locality for celestite, I have been unable to find the original source§ for such a reference. Neither Cleveland‖ nor Beck¶ refer to Syracuse in this respect. This, therefore, is the first time that a detailed description of this occurrence of celestite is given.

This mineral was first found about three-quarters of a mile north of the village of Jamesville, near where the electric railroad crosses the turnpike to De Witt. At this point quite a heavy grade is encountered by the railroad and a considerable amount of rock—the drab limestone of the Salina epoch—had to be removed in order to allow the railroad to run parallel to the turnpike for about three-quarters of a mile. The cut varies from about two to six or eight feet in some places. In the rock which was removed, and also along the sides of the cut, the fresh mineral was found in a surprisingly large quantity.

The mineral does not occur in veins or cavities, as might be supposed and as is usually the case, but it is found disseminated throughout the rock. The character of the dissemination varies greatly with the locality and horizon in which the celestite is found. Three distinct types of dissemination were noticed. 1. In some cases the mineral has had ample time to assume well-defined crystal forms, which may in many instances be from one-half to one inch in length. This type of dissemination is shown by figs. 1 and 2. 2. In other places the crystallization was more rapid, and many crystals of a smaller but practically uniform size, one-eighth to three-eighths of an inch, resulted. Fig. 3 shows this type of dissemination;

* Read in abstract before the Onondaga Academy of Science, February 19, 1904.

† Dana, System of Mineralogy, 6th edition, 1892, 1063.

‡ Whitlock, New York Mineral Localities, New York State Museum Bulletin No. 70, 1903, 54.

§ Whitlock in a letter to me, concerning the mentioning of Syracuse as a locality for celestite by Dana, who is his authority, says: "It is possible that the notice of this locality was communicated by some local observer." This would, of course, account for the fact that nothing published can be found.

‖ Cleveland, Mineralogy, 1822.

¶ Beck, Mineralogy of New York, 1842.

the fresh mineral can be seen to the left. 3. The mineral may also occur disseminated not in the form of well-defined crystals but rather in small circular spots, which in some cases are about uniform in size, while in other instances

1 2

they may vary from three-sixteenths of an inch down to a needle-point. Figure 5 illustrates this occurrence of the mineral. No doubt the crystallization was so rapid that it was impossible for the mineral to assume well-defined forms.

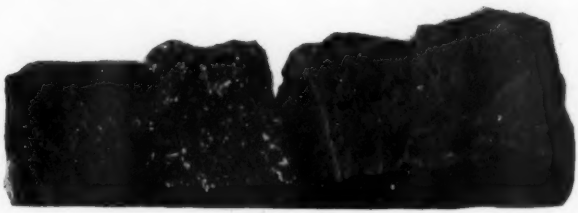
3

In the first two types of dissemination the orthorhombic character of the crystals is very easily recognized. The mineral is also characterized by a slight blue tint.

Numerous attempts were made to isolate crystals so as to make goniometric measurements. In every case, however, the crystal faces were dull and gave no reflections whatever. The

various faces could, nevertheless, by means of the cleavages parallel to the basal pinacoid and the unit prism, be determined with considerable accuracy. A very common combination of faces consists of the unit prism, *m* (110); macrodome, *d* (102); brachydome, *o* (011); and the brachypinacoid, *b* (010), and the basal pinacoid, *c* (001). This combination is a usual one with celestite.

4 5 6



The specific gravity of this celestite was determined by means of a Jolly balance of the Linebarger pattern. The mean of several determinations was found to be 3·958. This agrees very closely, indeed, with the normal specific gravity, 3·962, as given by Kopp.* The mineral not only conforms to the physical properties of celestite, but to the qualitative chemical as well. I shall report later as to the quantitative chemical composition.

As already indicated, the mineral was first found near where the electric railroad crosses the turnpike to De Witt. It occurs here in what Vanuxem calls the "Magnesium Deposit." Vanuxem† divides the Salina epoch into four divisions or deposits. He says: "The first or lowest deposit is the red shale, showing green spots at the upper part of the mass. Secondly, the lower gypseous shales, the lower part alternating with the red shales, which cease with this mass. Thirdly, the gypseous deposit, which embraces the great mass quarried for plaster, consisting of two ranges, between which are the hopper-shaped cavities, the "Vermicular Limerock" of Eaton, and other porous rocks. Fourthly and lastly, those rocks which show groups of needle-form cavities placed side by side, caused by the crystallization of sulphate of magnesium, and which may from that circumstance be called the 'Magnesium Deposit.'" The "Magnesium Deposit" is included in the "Gypseous Shales" of Luther.‡ The celestite is, however, not confined to the "Magnesium Deposit," for it was also observed in other localities in Vanuxem's "Third Deposit." I was subsequently

* Naumann-Zirkel, Elemente der Mineralogie, 13th Auflage, 1895, 549.
† Vanuxem, Natural History of New York, Third District, 1842, 95.
‡ Luther, Economic Geology of Onondaga County, 264.

able to observe celestite in many places southeast of Syracuse, principally, however, at Dunlop's quarry and in the vicinity of the Rock Cut on the D. L. & W. R. R. Later, Prof. T. C. Hopkins of Syracuse University noticed it near Split Rock in the drab limestones of the Salina along the cuttings of the new Auburn and Syracuse railroad. Although I was unable to make an exhaustive study last fall of its distribution, I do not doubt, whatever, but that its occurrence in the disseminated condition, as shown by the accompanying figures, is just as extensive in the limestones of the Salina elsewhere, as in the vicinity of Syracuse.

Beck in his "Mineralogy of New York"* says: "Celestite is usually associated with limestones, but that it does not seem to be peculiar to any geological epoch." He mentions but one occurrence in the dark Salina limestone, which is on the Owasco Outlet, near Auburn. Whether the mineral occurs in this locality disseminated throughout the rock, or in cavities and veins, neither Beck nor Whitlock† states with definiteness. From the general description which they give, one is led to believe that at this locality it is of secondary formation, that is, in veins or cavities. All the other occurrences in New York State which are mentioned by Beck and Whitlock (there are nine (9) of them) are in other epochs and without an exception secondary formations.

The occurrence at Dunlop's gypsum quarry, about one-half to three-quarters of a mile to the northeast of the locality where celestite was first found, is extremely interesting. It was impossible for me during my visits to this quarry to observe the rock containing the celestite *in situ* on account of the fact that the strata above the gypsum were for the most part covered with soil or other earthy material. The dump piles, however, contain a great many rock fragments, which show large quantities of the fresh mineral. The specimen shown in fig. 3 is from this locality. The crystals are rather small, one-eighth to three-eighths of an inch in length and, where the rocks have been exposed to the weathering agencies, the crystals on the outside have entirely disappeared, leaving very unique cavities. The cavities, nevertheless, betray by means of their distinct outline what the original material was, for the orthorhombic character as well as the various faces may be easily recognized. These cavities might at first sight appear to be bird tracks or something of that character, but as said, it can be easily shown that they are crystal cavities. That this is the case can be proven beyond a doubt by breaking the specimen, as has been done in fig. 3, and we find that the mineral is

* Page 210.

† Whitlock, New York Mineral Localities, 1903, 22.

still present in the interior—to the left—in well-defined crystals, while on the outside, as a result of leaching, only the crystal cavities are to be seen.

Several specimens from the first locality show very large cavities, and their resemblances to the impressions made by chisel points does not seem to be farfetched. Figs. 7 and 8 show such "impressions" or cavities on the outside, while in figs. 1 and 2 the fresh mineral can be seen in the interior of these same specimens. Cavities of this character were noticed by Eaton, Vanuxem and others, for Vanuxem* says: "Near

7 8

Syracuse, at the Hopper locality in Onondaga Valley, and at Chittenango and so forth, surfaces are seen which show an angular configuration, somewhat resembling those leaves whose ribs are straight, and incline at an angle of about 35° from the stem. These were first noticed by Prof. Eaton in his survey of the Erie Canal, having seen some which were thrown out in digging a well at Syracuse, the cause of which was rightly referred by him to crystallization."

Vanuxem further says: "On the canal, near Lake Sodom, layers of a similar kind but belonging to a lower deposit show numerous cavities not unlike those made by a small chisel of about three-quarters of an inch in width; some of them single, and others cross each other as though struck at random. In the surface also of the calciferous slate above the gypseous deposit at Crill's in the town of Stark, there are small impressions in relief, the best defined of which are like obtuse Indian arrow heads, being triangular with their sides somewhat curved; these were previously noticed but not their forms." From this general description given by Vanuxem and also from the fact that Crill's farm in the town of Stark, Herkimer

* Vanuxem, Natural History of New York, Third District, 1842, 109.

County, is given as a locality for celestite by Beck and Whitlock, there is little doubt in my mind but that the investigators, mentioned above, had encountered specimens of the same character as those shown in figs. 7 and 8, and that the cavities and "impressions" were once filled by the mineral celestite, which was removed in the manner already referred to.

The third type of dissemination, referred to above, that is, in the form of small circular particles, as illustrated by fig. 5, is exceedingly instructive. When a rock which contains celestite in this form of dissemination is leached, it gives rise to a rock which appears as though it were worm-eaten. The lower portion of figure 5 shows the effect of such leaching and possesses a distinct porous structure. There is a very striking similarity between such a rock and the so-called "Vermicular Limestone" of Prof. Eaton and the older reports. This resemblance is shown very clearly in figs. 4, 5, 6; figs. 4, 6 being the so-called "Vermicular Limestone."

As regards the character of the rocks of the upper portion of the Salina, which contain the celestite, and which to some extent comprise the vermicular limestones, Luther* says: "The gypseous shales consist of fine-grained magnesium or dolomitic limestones in thin layers, masses of gypsum and gysiferous shale in two courses, separated by a bed of limestone forty to fifty feet thick. In the thicker and more compact layers of limestone, freshly broken blocks show the rock to be very dark, almost black in the interior, but after exposure the color changes to an ashen gray or medium dark drab, sometimes showing a slight pink shade. It is very much like hydraulic limestone in appearance, but the proportion of clayey admixture is so large as to injure or destroy its cohesive qualities. In the middle and lower beds it is frequently more or less porous or cellular. The cavities are sometimes an inch or more in diameter, very irregular and ragged in shape, and lined with a fine brown dust. When of this character, they are very unevenly distributed through the rock and most frequently are found on the surface of a layer or opening into a joint." (Compare with figs. 7, 8.)

"In other layers, the cavities are found to be much more numerous, occupying in the aggregate nearly one-half the space of the rock, and having the form of circular cells, with the diameter ranging from a quarter of an inch down to a needle-point. Usually the cells in a particular layer of limestone have a considerable degree of uniformity in shape and size, but occasionally the contrary is the case. They are smaller in the lower beds. *These cellular limestones are the 'Vermicular Limestones' of the older reports.*" See figs. 4 and 6.

* Luther, Economic Geology of Onondaga County, 264.

These "Vermicular Limestones" have given geologists much trouble as to a satisfactory explanation of their porous structure. Vanuxem speaks of the cause of their porous character in the following language: "The cells show that parts of the rock were disposed to separate into very thin layers, which project into the cells, an effect wholly at variance with aëriform cavities, whose removal caused the cells in question. This view appears to be fully confirmed by the discovery in this rock of those forms which are due to common salt, showing that a *soluble saline material* had existed in it, had acquired shape in the rock, and had subsequently been dissolved, leaving a cavity or cavities." * The discovery at Livonia, N. Y., of such a cellular rock filled with salt seems at first to support Vanuxem's theory to a very considerable extent. Of this rock filled with salt, Luther† says: "In the shaft sunk to the rock salt beds at Livonia, N. Y., at the depth of 1,396 feet, thirteen feet above the salt bed, a stratum of the cellular, magnesium limestone was reached, in which the cells were filled with salt. A large block was placed in a running brook, and in a few hours the salt had been dissolved out, leaving the rock in precisely the same condition that it presents when found in loose fragments or in the outcrops in this (Onondaga) County."

It seems almost impossible to conceive how the very soluble sodium chloride could be disseminated through a rock, as would be necessary to give rise to this peculiar porous structure of the "Vermicular" limestones, as is clearly illustrated by figs. 4 and 6. Certainly such a deposition of salt would not be in harmony with the now generally accepted theory of Ochsenius‡ as to the formation of salt deposits, as we find them in New York State, Stassfurt in Germany, and elsewhere. I believe that sodium chloride is an altogether too soluble salt to have been the original occupant of these many cavities of the "Vermicular Limestones."

According to Wackenroder,§ celestite is slowly, but completely, soluble in water containing sodium chloride in solution. Virck‖ says, that 100 parts of water containing 15·54 per cent of sodium chloride dissolve 0·2186 grams of strontium sulphate, which is the composition of celestite. The same authority says, that it is even more soluble in water containing magnesium chloride, and not quite so soluble in water containing calcium chloride.

* Vanuxem, Natural History of New York, Third District, 1842, 101.

† Luther, Economic Geology of Onondaga County, 1895, 265.

‡ C. Ochsenius, Die Bildung der Steinsalzlager und ihrer Mutterlaugensalze. Halle, 1877. Kemp, Handbook of Rocks, 1900, 78.

§ Comey, Dictionary of Chemical Solubilities, 1895, 455.

‖ Ibid., 1895, 455, also Chemisches Centralblatt, 1862, 402.

That many of the rocks of the gypseous shales contain, or did contain salt, is evidenced by what Luther* says: "In the beds of limestone lying between the principal gypsum deposits, and more abundantly in that underlying the gypsum beds, hopper-shaped mud casts of what are supposed to have been salt crystals are numerous. *They are found in both the cellular and non-cellular layers.*" The presence of the magnesium and calcium chlorides is easily proven by referring to the many excellent analyses of the brines of this state, as also to those of the salt manufactured from them. The following analyses† represent typical brines from the principal salt-producing sections of the state.

	Wyoming Valley	Genesee Valley	Onondaga.	
$CaSO_4$	0·3083	0·5790	0·3632	0·5440
$CaCl_2$	0·5268	0·4650	0·5701	0·1340
$MgCl_2$	0·1034	0·2125	0·2852	0·1790
$NaCl$	23·5819	25·3199	18·4277	18·0560
H_2O	75·4796	73·4234	80·3538	81·0870

Englehardt, Bishop and others† believe that the chlorides (magnesium and calcium) are derived from the rocks overlying the rock salt deposits. Englehardt thinks that the quantity of calcium sulphate is dependent upon the amount of these chlorides present.

These analyses show that the meteoric waters passing through the rocks of the upper portion of the Salina, since they contain sodium, magnesium, and calcium chlorides in solution, ought to, according to the authorities cited above, be good solvents of celestite. Then, if it be true that celestite can be quite readily dissolved in such a circulating water, it is not unreasonable to believe that strontium should be present in the brines of this vicinity.

Through the courtesy of Mr. John D. Pennock, chief chemist of the Solvay Process Co., Solvay, N. Y., I was able to procure a sample of the brine which that company obtains from its wells at Tully, N. Y., a short distance south of Syracuse. The brine is not formed by a true meteoric water, but according to Hazard,§ "fresh water is introduced into the wells, where it dissolves the salt, and is forced to the surface in the form of a saturated brine." It is, therefore, evident that such a brine would not show as large an amount of stron-

* Luther, Economic Geology of Onondaga County, 1895, 265.

† Merrill, Salt and Gypsum Industries of New York, State Museum Bulletin No. 11, 1893, Table of Analyses by Dr. F. E. Englehardt opposite page 38.

‡ Ibid., No. 11, 1893, 62.

§ Luther, Economic Geology of Onondaga County, 1895, 257.

tium as would be the case if the water were in contact with the limestones overlying the rock salt beds for a considerable length of time.

I am indebted to Professor F. A. Saunders of Syracuse University for a very careful spectroscopic examination of this Tully brine. The spark spectrum was produced by means of a Rowland concave grating, using a scale which was sufficient to give a visible spectrum of about fourteen inches. From the study of the negative of this spectrum, it was shown that all the characteristic lines of strontium were strongly developed, and clearly revealed the fact that strontium is actually present in this artificial brine in more than a spectroscopic trace. Not only is strontium present but a trace of barium was also noticed. After having communicated the fact that strontium is present in the Tully brine to Pennock, he was able to confirm Saunders's observation. Strontium is not indicated in the analyses of Englehardt, given above, on account of the fact that it was not tested for, and is, therefore, estimated with the calcium; hence the amount of $CaSO_4$ is necessarily a trifle too high. As to the amount of strontium, calculated as sulphate, present in the above brine, I shall report later. I have not been able, as yet, to examine the brines from the wells on the Onondaga Salt Reservation, which are formed by true meteoric waters, because the wells are shut down during the winter months.

With the following facts in mind, (1) that celestite is quite soluble in water containing sodium chloride, magnesium chloride or calcium chloride in solution, and (2) that the dissemination of celestite through the rock is not at all unlike that which would be necessary to form cavities as found in the "Vermicular" Limestones, (3) also that when such a rock has been leached the appearance of the resulting rock is exactly like that of these so-called "Vermiculars," and (4) that the brines of this vicinity do contain a considerable amount of strontium, also traces of barium, which is isomorphous with strontium and usually replaces it to a small extent in celestite, and (5) the finding in that "Vermicular," which outcrops in various places in Syracuse and vicinity, of cavities with such forms as would be produced by the leaching of celestite crystals,* we cannot but come to the conclusion *that these many cavities, now empty, in the "Vermicular Limestone" of the Salina Epoch must have once contained a mineral of the char-*

*The specimen of fig. 5, is from E. Adams St. near Irving Ave., Syracuse. A study of the cavities on the surface of this rock, which is locally known as "the vermicular," reveals those forms which are so characteristic of celestite. They are not unlike those of fig. 3, where the fresh material is still present in the interior.

acter of celestite, and that by the action of the agencies, mentioned above, the same was dissolved, leaving nothing but the so-called cells to show its former presence. I do not believe that the salt found in the rock in the shaft at Livonia, N. Y., is the original occupant of the cavities, but rather that it is of secondary formation, having been derived from the rocks above, which Luther says contain many mud casts at this locality. When the salt is leached from this rock, many of the resulting cavities show the characteristic outline of the celestite crystals and also possess that weathered appearance which is so peculiar to the cavities of the "Vermiculars."

During the coming summer I intend to continue my study of the distribution of the celestite-bearing limestones, and also the brines of the state as to the amount of strontium they contain. I will report as soon as possible.

In conclusion, I wish to thank my colleague, Mr. C. L. Hewitt, for the very valuable services he rendered in making possible the excellent illustrations which accompany this paper.

Syracuse High School, March, 1904.

Art. VII.—*A Famous Fossil Cycad;* by Lester F. Ward.

There is in the Museum of Mineralogy and Geology at Dresden a petrified trunk of a cycad that has been known for more than two centuries and a half. It is the type and only known specimen of *Cycadeoidea Reichenbachiana* (Göpp.) Cap. and Solms, the *Raumeria Reichenbachiana* of Göppert. It has the longest history of any specimen of its class, unless we count as history the thousand years or more that the type of *Cycadeoidea etrusca* lay upon an Etruscan tomb at Marzabotto before it was discovered by Count Gozzadini in 1867 and found its way in 1878 to the Geological Museum of Bologna.

When in 1894 I made a voyage to Europe chiefly for the purpose of studying the collections of fossil cycadean trunks in the various museums preparatory to the elaboration of those of America, I was not able to visit Dresden and see this specimen. In 1898 Dr. H. B. Geinitz sent me a photograph of it as it stood in the Dresden Museum resting on a wooden pedestal made to support it. This I reproduced in my memoir on the Cretaceous Formation of the Black Hills as indicated by the Fossils Plants,* explaining the circumstances in the text.† The photograph was not particularly clear and was of a light brown color, somewhat pale. The half-tone process by which it was reproduced brought out much that was latent in the photograph and the result is a considerably better view than the original. In studying this it was clear both that the petioles were descending and also that the sharp angle of the leaf scars was on their upper side, both of which features are very rare in cycad trunks. This raised the suspicion that the specimen might be inverted, and led me to remark in the footnote on page 605 of that memoir that, judging from the picture alone, "I should say that the trunk is here inverted, but to be certain it would be necessary to examine it. It is clear that in the present position the leaf scars have a decided downward direction, which is rare but not unknown (e. g., *C. Uhleri*). Moreover, the scars, which are subtriangular, have now their sharp angle upward, which, if the specimen is right side up, would indicate that the keel of the petioles was on the upper side, a condition which I have met with in only two other species, *C. aspera* and *C. insolita*."

On August 27, 1903, on my way from Vienna to Berlin, I stopped at Dresden and visited the Royal Museum. I readily found the specimen still standing upon the same support as when photographed by Dr. Geinitz. A glance at it was suffi-

* Nineteenth Ann. Rep. U. S. Geol. Surv., 1897–98, pl. lix.
† Ibid., pp. 601, 604, 605.

cient fully to justify the suspicion expressed in the above-quoted footnote, and it was clear that it stood on the somewhat even face presented by the transverse fracture through the middle of the trunk, while the much less even base, which, if the specimen had been placed in its natural position, would have required it to be supported by wedges or cement, was uppermost and distinctly showed its character as such. Dr. Johannes Victor Deichmüller, Directorial Assistant, who, in the temporary absence of the Director, was in charge of the Museum, and to whom I announced the object of my visit, was much interested in my account and kindly caused the specimen to be placed on a table where I could thoroughly examine all parts of it. I proceeded to describe it in my note-book, in which I systematically recorded all the visible features in the same manner as I have done for all the American trunks. As the specimen is regarded as constituting a species, and does, indeed, differ specifically from all others thus far known, these notes upon it form an adequate basis for the specific description. Before dealing with the systematic part, however, it will be of interest to give a somewhat detailed historical account of the specimen.

I. *History and Literature.*

Desiring to learn the authentic history of the discovery of this specimen and its removal to the Dresden Museum, I wrote to Dr. Deichmüller on my return to America, giving him such bibliographical references as I was able to find and requesting him to consult if possible the original publications. He was successful in finding the most important of the early documents, namely, the report of Christian Heinrich Eilenburg, who was the Director of the Dresden Museum at the time this specimen was acquired. It is printed in German and French and bears the following title:

Kürzer Entwurf der Königlichen Naturalienkammer zu Dresden. Dresden und Leipzig, in der Waltherischen Buchhandlung, 1755.

oder:

Description du Cabinet royal de Dresde touchant l'histoire naturelle. A Dresde et à Leipzig, chez George Conrad Walther, libraire du roi, 1755.

Dr. Deichmüller had the great kindness to copy out of this work and send me the following passages relating to the object under consideration:

"A large case in the sixth arcade contains petrifactions from the vegetable kingdom, which always fixes the attention of connoisseurs. That which is most admired here is a magnificent

block of petrifactions which M. Borlach, Counsellor of Mines, sent us from Poland. It weighs over 100 pounds, and is, in our opinion, only a mass of petrified Hippurites, or coral-cups, although a celebrated naturalist entertains the view that this superb mass may be the summit of a palm tree turned to stone." (P. 23 of the French and p. 24 of the German).

Dr. Deichmüller also found in the library of the Dresden Museum the original manuscript catalogue in Eilenburg's handwriting and never published, bearing the title: "Lithoxylorum seu lignorum petrefactorum varii generis variæque speciei Catalogus Novus in quo simul osteocollarum et lignorum fossilium præsens collectio indicata est a Christiano Henrico Eilenburgio, MDCCLIII." On page 41 of this catalogue occurs the following entry written in Latin: "No. 76. A segment certainly of petrified palm wood, the fibers and stems so distinct that they would be taken for combustible wood unless the contrary is shown by handling and weighing. A certain projecting knot surrounded by regularly arranged natural rows and fibers calls for special attention in this remarkable petrifaction; but the structure is the same above and below and such that we are able to see that it penetrates through the entire thickness of the trunk. From Poland."

The specimen was first figured by George Wolfgang Knorr in his well-known "Sammlung von Merkwürdigkeiten der Natur und Alterthümern des Erdbodens oder versteinte und andere gegrabene Cörper in illuminirten Kupfertafeln," of the text for which he only lived to write the first fascicle of 36 folio pages (Nürnberg, 1755). This did not include the description of this specimen. The remainder of the text was written by Johann Ernst Immanuel Walch, and published as a separate work with the title: Die Naturgeschichte der Versteinerungen zur Erläuterung der Knorrischen Sammlung von Merkwürdigkeiten der Natur, Nürnberg, Erster Theil, 1773, Zweyter Theil, Erster Abschnitt, 1768, Zweyter Abschnitt, 1769, Dritter Theil, 1771, Vierter Theil, 1773. This work is usually preceded by Knorr's fascicle and accompanied by the atlas as a separate volume, the whole being known as the work of Knorr and Walch. The plates of the atlas are numbered in an almost incomprehensible manner, but the figure occurs on Plate III*a* of the Supplement, which is really the 220th plate of the work, of which it is figure 6. No one who has seen the specimen would ever recognize this as being a figure of it, as it does not show either the shape or the markings at all correctly.

In Walch's description of it, which occurs on pages 150–152 of the third part, nothing is said of the defects of Knorr's figure, and he confines himself to a general treatment of the specimen. He quotes extensively from what he calls "Rath

Eulenburg's Beschreibung der Dresdner Naturalien-Cammer," especially, p. 24. This work is therefore apparently the same as that of which Dr. Deichmüller has furnished me the title, but it seems to contain much additional information relative to this specimen. From the account here given and from all other available sources we learn that the specimen was found in 1753 by a man named Schober in a swamp near Lednice, a small village in the salt region, about three miles E. S. E. of Wieliczka, in Galicia, and therefore only about fifteen miles in nearly the same direction from Cracow. This swamp is said to lie 500 feet above the level of a small stream, tributary of the Weichsel, which flows through that country within a mile of the spot. It was not, however, supposed that this swamp was the original source of the cycad, as there are no rocks near there and the formation consists of simple clay soil. It was supposed therefore that it had been brought there by the peasants who were accustomed to utilize the swamp in macerating their hemp. But there was said to be some higher ground not far distant where there are hard rocks, and where, in fact, a small piece was found resembling the cycad in structure. If so this is probably the source of the latter.

A mining engineer named Borlach in some way obtained possession of the specimen and sent it to Dresden, where it was placed in the Natural History Cabinet which has developed into the present Museum of Geology and Mineralogy, occupying the southwest portion of the Zwinger. Borlach left manuscript notes with the specimen giving most of the above-mentioned details and also indulging in some speculations as to the nature and significance of the specimen, which are tolerably free from the crudities of most of the discussions of his time relative to this class of objects. He queries, for example, whether it is a marine plant, or the nest of some marine animal, or a petrified land plant such as the top of a palm tree. He seems to incline to the last of these suppositions, but says that if it really be a petrified palm the climate must have been hot at the time it grew, from which he infers that the earth must have changed its axis since that time. It is probable that Borlach is the person to whose opinion to this effect Eilenburg refers in the passage quoted above from his report.

Eilenburg describes the specimen in considerable detail, says that it is irregularly broken at both ends, has a cylindrical but somewhat oval shape, is 22 inches in major and 20 inches in minor diameter and 24 inches high, is of a black color, though brownish at one end, has the hardness of agate or flint, and takes a fine polish. If a small piece be detached and thrown into the fire it becomes ash gray and gives off the odor of brimstone, but remains firm and does not burst like other hard

stones. He describes the surface of the specimen as covered with holes somewhat systematically arranged, sometimes in groups having the shape and size of a walnut, except that in some cases there rises in the middle on the longer side a rounded boss [this must refer to the reproductive organs]. The areolæ are described as oval and penetrating two to three inches into the stone, diminishing in size with the depth. But in some, he says, there is a nucleus [leaf base] of the same material as the rock, except that it possesses small longitudinal pores. Besides the larger cavities there are other much smaller ones of the size of a pea arranged in elliptical concentric groups, some of which are compressed [bract scars]. In some places are to be seen special growths, so to speak, having the form of buds which have not yet opened and only slightly project. Some of these smaller cavities have porous nuclei resembling grains of barley, but most of them are empty. In one spot on this rare petrifaction, he adds, a piece of the rock has fallen out leaving a funnel-shaped depression two to three inches deep, the sharp end being directed toward the axis.

Eilenburg, as we have seen, adopted the view that the petrifaction represented a hippurite or coral, but at that day these objects were referred to the vegetable kingdom.

On page 150 of Walch's work it is stated that the specimen was found in 1751, but on the next page it is said in Borlach's notes that it was found "erst in diesem Jahre." As all accounts agree that it was sent to Dresden by Borlach in 1753, this would also seem to be the date of its discovery. It is, however, possible that Borlach wrote these notes two years earlier.

Dr. Deichmüller finds a note appended to the entry above quoted in Eilenburg's manuscript catalogue, which reads as follows: "We take pleasure in referring in this connection to the able work of P. Gabr. Rzaczynsky: *Historia naturalis curiosa regni Poloniæ*, 1721, printed at Sandomir, where on pages 5–117, is to be found a more complete account of the petrified wood (*Lithoxylis*) discovered in Poland." From this entry Dr. Deichmüller thinks it not impossible that this specimen may be treated in Rzaczynsky's work as early as 1721. This does not seem probable from the above account, but it is greatly to be hoped that this work may be found and examined from this point of view.

The specimen lay in the Dresden Museum for nearly a century without receiving further attention. In 1844 Göppert seems to have already named and described it, for in his contribution to the second edition of Wimmer's Flora von Schlesien, vol. II, p. 217, where he describes the genus Raumeria and names *R. Schulziana* (found near Gleiwitz in Silesia), he adds a note in which he says that "the celebrated

cycadean trunk at Dresden belongs to the same genus (*Raumeria Reichenbachiana* Göpp. manuscript)." It was, however, nine years before the description and illustration appeared. Meantime Unger listed it in his Synopsis Plantarum Fossilium, 1845, p. 163, and in his Chloris Protogæa of about the same date, p. LXV. Göppert also put the name in his list contributed to Bronn's Handbuch (vol. II, Abth. II, Th. III, Index palaeontologicus, 1848), both in the Enumerator, p. 38, and the Nomenclator, p. 1078, referring it to the lower "Molasse" or Miocene. The naked name occurred at least four times more, viz., in Unger's Genera et Species Plantarum Fossilium, 1850, p. 301; in the same author's work: Die Pflanzenwelt der Jetztzeit in ihrer historischen Bedeutung, 1851, p. 230; in Massalongo's Conspectus Floræ Tertiariæ Orbis Primævi, 1852, p. 12; and in Giebel's work: Deutschlands Petrefacten, 1852, p. 91; before Göppert's descriptive paper: Ueber die gegenwärtigen Verhältnisse der Paläontologie in Schlesien so wie über fossile Cycadeen, in which the specimen was fully treated, finally appeared in the Jubiläums- Denkschrift der schlesischen Gesellschaft für vaterländische Cultur, Breslau, 1853, pp. 251–265, pl. vii–x.

In this paper we have a somewhat adequate description of the specimen accompanied by five figures (pl. viii, figs. 4–7; pl. ix), which, Göppert says, were furnished by Geinitz. He dedicates the species, however, to Reichenbach, long Director of the Dresden Museum, who, he says, had always afforded him free access to the collections. From this we must infer that he had studied the specimen himself at first hand. His historical account is very brief, referring chiefly to Walch's description, but making no mention of Eilenburg's.

He says that the trunk is cylindrical, 24 inches high, 20–22 inches in diameter, transformed into an entirely black, chert-like mass, showing very little structure. He classes it as the trunk of a cycad and compares it with that of *Cycas revoluta*, reproducing for comparison Vrolik's figure of a somewhat remarkable specimen of that species (pl. x, fig. 3). He also compares, or rather, contrasts it with *Cycadeoidea microphylla* of Buckland, reproducing (pl. x, fig. 2) his figure in the Bridgewater Treatise, vol. II, pl. lxi, fig. 1. He recognizes the scars as those of the petioles, and says some are from one to two inches deep. The prominent reproductive organs could not, of course, have failed to attract his attention, and he refers to them as the small scars that take the place of the large ones and arrange themselves in circular or elliptical groups, which he regarded as perhaps representing spots where buds are breaking through. Such buds, he says, really seem to have been present here. He seems to have no idea of their being

reproductive organs, and compares them with those of both *Cycadeoidea microphylla* and *Cycas revoluta*, saying that as the buds grow out branches are formed.

The principal figure of the trunk (pl. viii, fig. 4), furnished, as he says by Geinitz, represents, about one-eighth natural size, the side opposite to that shown in the photograph sent me by Geinitz. The specimen here stands more erect, and though inverted shows less of the base. Fig. 5, which Göppert calls the "obere Querschnitt," is a view of the base, and the structureless area on the upper left portion represents a large oblique fracture, which I described as the loss of a "large piece extending to the medulla and running out 28^{cm} above, with a width of 43^{cm}." Plate ix represents natural size an area 20^{cm} wide and 215^{mm} high near the base, which is still at the top of the figure, showing several of the larger reproductive organs, one of which, though here drawn as if the spadix had fallen out, is of special interest in showing a radiate structure with carpel-like partitions that may contain seeds.

Plate viii, figs. 6 (natural size) and 7 (somewhat enlarged) represent a cross section of a small piece from this trunk, apparently a leaf scar containing the base of a petiole, which Göppert says was sent him by Reichenbach at an earlier date, and which he seems to have cut transversely and figured himself. He recognizes resin ducts and parenchymatous cells, but finds no vascular bundles. I was myself unable to see any vascular bundles in the leaf bases. They are either indistinguishable from the parenchyma or else they lie close to the walls and blend with the partition lines.

In 1858 Geinitz issued one of the reports on the Dresden Museum which bear the title: Das Königliche Mineralogische Museum in Dresden, in which he gave a succinct history of the Museum from its earliest beginnings. It does not, however, contain any of the above facts relative to this specimen, which is only once mentioned (p. 17), in connection with the great three days' fire of 1849, during which the greater part of the collections thus far accumulated were destroyed. "Only one specimen, the precious *Raumeria Reichenbachi* Göppert, a cycad from Wieliczka, remained unscathed under the protection of a sandstone pillar."

The next mention that I find of this species is in Miquel's Prodromus Systematis Cycadearum, published at Utrecht and Amsterdam in 1861 (p. 29). It adds nothing to the knowledge of it.

Equally without significance is the allusion to it by Geinitz in his Dyas (Heft II, 1862, pp. 148, 341), except for his reference of it to the Permian, which was only a guess and of course a wrong one.

Carruthers in 1870 described the species twice in his well known paper on Cycadean Stems from the Secondary Rocks of Britain (Trans. Linn. Soc., vol. XXVI, pp. 682, 704), but does not appear to have seen the specimen. He says that the formation is unknown. Schimper also described the species in 1870 (Paléontologie Végétale, vol. II, p. 189), but he distinctly stated that he had not seen the fossil and could only copy Göppert's diagnosis.

Geinitz, in his report on the Dresden Museum bearing the same title as the one previously mentioned, but dated 1873, gives a short bibliography but, as it seems, inadvertently omits the title of Göppert's paper above treated, in which this specimen was first described. This omission he supplies by publishing a supplementary page dated January 12, 1874. This he was kind enough to send me at the same time as the photograph.

Count Solms-Laubach examined this trunk and was the first to point out that Göppert's whorls of small scars represent the lateral fruit-bearing axes (Einleitung in die Paläophytologie, Leipzig, 1887, p. 102). He did not therefore hesitate to class it as a Bennettites as Carruthers had defined that genus.

In 1892 Capellini and Solms-Laubach referred this species to Buckland's genus Cycadeoidea (I tronchi di Bennettitee dei Musei Italiani, Mem. Real. Accad. Sci. dell' Ist. di Bologna, Ser. V, Tom. II, p. 188), in which I have followed them in all my papers where I have had occasion to mention it (Proc. Biol. Soc. Washington, vol. IX, April 9, Washington, 1894, p. 85; Proc. U. S. Nat. Mus., vol. XXI, No. 1141, Washington, 1898, p. 198; Nineteenth Ann. Rep. U. S. Geol. Surv., 1897–98, Washington, 1899, pp. 601, 604, 605, pl. lix).

II. *Geological Position.*

It will be seen from the above sketch of the history of this specimen that the geological formation to which it belongs is only twice alluded to, one of the references placing it in the Miocene and the other in the Permian. That it could have come from neither of these formations I have all along been satisfied, and from its close resemblance to the trunks found in the Lower Cretaceous of other parts of Europe, and especially of America, I have believed that if its true source should ever be discovered it would be found to be in beds of that age. As it was found in territory now forming a part of the Austrian empire, and as geological activity in Austria has been very great for many years, I hoped to find that the region around Lednice had been surveyed in a manner sufficently thorough to furnish the data for forming a judgment as to the true age of the beds in which it occurred. After some unsuccessful search among the voluminous reports of the Austrian Geological Survey, I

finally wrote to Dr. Emil Tietze, the distinguished Director of the k.k. geologische Reichsanstalt, to learn if possible whether this district had been surveyed and if so where I could find the report, maps, etc., He replied promptly and informed me that he had himself made this survey and published the results in 1887.*

In my letter to Director Tietze, dated November 12, 1903, I said:

"I note that most of the region about Cracow is mapped as Tertiary. It does not seem probable that the specimen could have come from the Tertiary, as all similar trunks, from whatever part of the world, have been found in much older strata, ranging from the Middle Jurassic to the Lower Cretaceous. The specimens most closely related to it in America occur in the Lower Cretaceous of the Black Hills, South Dakota."

In his reply of December 10, he says:

"The salt formation of Wieliczka is certainly Tertiary and Miocene. The *Cycadeoidea Reichenbachiana* surely does not come from this salt formation, the flora of which is in fact known from the works of Unger and Stur. But at Lednice the beds of the Miocene salt formation do not occur. There are developed partly Oligocene, partly Lower Cretaceous deposits. Probably, therefore, the specimen in question came from the Lower Cretaceous of Lednice. Still, I must admit that thus far the presence of fossil plants was not known here, and also that in the general region about Wieliczka such remains have heretofore scarcely been found. This is of course no reason for doubting their presence at this locality."

A glance at the fourth sheet of Dr. Tietze's Map (Jahrb. 1887, pl. xix), shows that beds colored for Neocomian occur at Lednice and throughout that general region, and it seems therefore next to certain that it was from these beds that the specimen was primarily derived.

III. *Systematic Treatment.*

Description of the Species.

Cycadeoidea Reichenbachiana (Göpp.) Cap. and Solms.

1755. Hippuriten oder versteinerte Corallenbecher Eilenburg : Kürzer Entwurf der Königlichen Naturalienkammer zu Dresden, p. 24.

1771. Vegetabilische Versteinerung Walch: Die Naturgeschichte der Versteinerungen zur Erläuterung der Knorrischen Sammlung von Merkwürdigkeiten der Natur, Pt. III, p. 150 ; Atlas, Supplement, pl. III*a*, fig. 6.

* Die geognostischen Verhältnisse der Gegend von Krakau. Von Dr. Emil Tietze. Jahrb. d. k.k. Geol. Reichsanstalt, XXXVII. Bd., 1887, Wien, 1888, pp. 423-838. 4 maps.

1844. Raumeria Reichenbachiana Göppert in Wimmer: Flora von Schlesien, Ed. II, vol. II, p. 217 (nomen).

1853. Raumeria Reichenbachiana Göpp.: Jubiläums-Denkschrift d. Schles. Ges. f. vat. Cult., p. 262, pl. viii, figs. 4–7; pl. ix.

1892. Cycadeoidea Reichenbachiana (Göpp.) Cap. and Solms: Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, p. 188.

1894. Cycadeoidea Reichenbachiana (Göpp.) Cap. and Solms. Ward: Proc. Biol. Soc. Washington, vol. IX, p. 85.

1899. Cycadeoidea Reichenbachiana (Göpp.) Cap. and Solms. Ward: Nineteenth Ann. Rep. U. S. Geol. Surv., 1897–98, pp. 601, 604, pl. lix.

Trunks large, cylindrical or subconical, little compressed, the longer diameter 54^{cm} at the base and 52^{cm} near the middle, the shorter 44^{cm} at the base and 42^{cm} near the middle, unbranched; rock very hard and chert-like, black, becoming light gray on long exposed surfaces, fine-grained, breaking with a conchoidal fracture, of high specific gravity; organs of the armor all slightly and uniformly ascending; phyllotaxy much interrupted and irregular but consisting of two spiral rows of which those from left to right form an angle of about 45°, and those from right to left of about 25° or 30° with the axis, the former much more clear; leaf scars subrhombic, the lower angle obtuse, the two upper sides commonly reduced to a curve or arch, somewhat uniform in size, averaging 25^{mm} in width (but showing extremes ranging from 15^{mm} to 30^{mm}) and 13^{mm} in height showing extremes from 10^{mm} to 20^{mm}; leaf bases usually visible at the bottom of deep areolæ, the depth varying from 2^{cm} to 6^{cm}, probably all disarticulated at a natural joint, the somewhat spongy or porous interior inclosed in a sheath of firm, fine grained material which itself consists of two plates, the two together about 0·5^{mm} thick; vascular bundles invisible, perhaps inclosed between the two plates of the sheath; walls very thick but varying from 2^{mm} to 15^{mm}, averaging about 1^{cm}, rough and irregularly grooved on the outer surface, sometimes showing a median line, often traversed by bract scars; reproductive organs very large, numerous and prominent, distorting the arrangement of the leaf scars, elliptical in cross section, the longer axis often 7^{cm} or 8^{cm}, the shorter 4^{cm} or 5^{cm}, but varying greatly in size and sometimes appearing to coalesce; involucral bract scars numerous and conspicuous, covering most of the surface of the trunk, spirally arranged around the spadices but straggling out over the surface of the walls, semilunar, triangular or subrhombic, rather small (3^{mm} to 6^{mm} long, 1^{mm} to 3^{mm} wide); central portion of the inflorescences often covered with scars or markings, sometimes solid and raised 1^{cm} to 2^{cm} above the general surface, a few concave and showing a radiate

carpellary structure suggesting the presence of contained seeds; armor very thick (5^{cm} to 10^{cm}), its attachment to the axis obscure and apparently indefinite; woody cylinder about 8^{cm} thick, uniform in color and texture and showing on the rough fractures no subdivisions or rings; medulla about 13^{cm} in diameter and nearly circular in cross section, hard, black, and homogeneous in structure, which differs little in appearance from that of the wood.

The only specimen of this species known is the one in the Dresden Museum of which the history is here recorded. It consists of the basal portion of a very large trunk of unknown height and of which the exact form of the upper part is also of course unknown, but from analogy with the hundreds of specimens of cycads which are now known from different parts of the world, it is tolerably safe to infer that the specimen represents at least half the length and that the top was conical or dome-shaped. The fracture through the middle portion is a little oblique so that the specimen leans somewhat. It is nearly even, but not wholly so, the central part of the piece preserved being somewhat higher than the part next to the surface so as to make it slightly arched or convex in the middle, sloping gently away from the center in all directions, the elevation amounting to about 4^{cm} or 5^{cm}. The specimen seems to have always been placed on this square end, apparently for no better reason than that it would thus stand without having to be blocked up, as would have been necessary if it stood on its much less even base. The base, as shown by the figures, is imperfect from the loss of numerous chips and splinters on one side and of the large piece on the other to which mention has already been made (supra, p. 46).

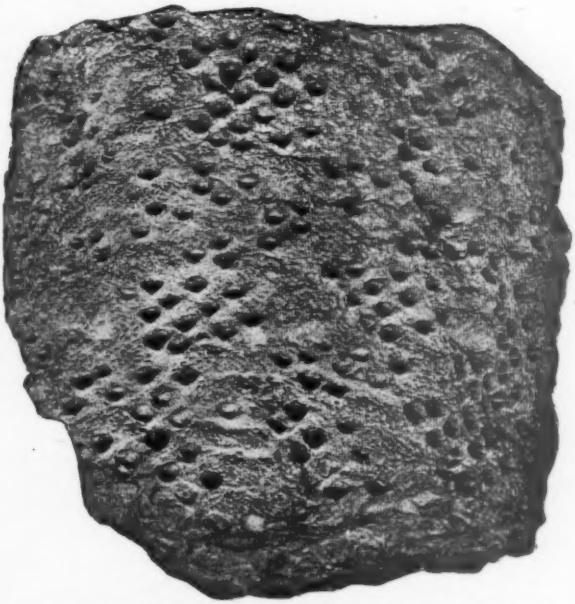
The specimen has not been weighed so far as known unless this was done soon after it was sent to Dresden, and if so the exact weight was not recorded, the only reference to the weight being that of Eilenburg who says that it is "über einen Centner schwer" (ibid, p. 24), which is repeated by Walch (op. cit., p. 150). This estimate was certainly much too small, whether we make the Centner 100, 112, or 120 pounds. The specific gravity is about the same as that of the type specimen of *C. Jenneyana* and it is somewhat larger than the basal piece of that specimen, which weighs 95·26 kilograms, or nearly 210 pounds.

Of all the species known to me *C. Jenneyana* is the one that *C. Reichenbachiana* most closely resembles, but as the above description clearly shows, it is certainly distinct from that species and is probably distinct from all other species thus far described.

After having taken full notes of the specimen, from which I have been able to make the above description, I drew the spe-

cial attention of Professor Deichmüller to the most promising of the reproductive organs, and at my indication he marked several of these with red chalk. Should any one ever undertake the study of its internal structure these should be specially investigated. Of course I cannot promise that they would be found to contain seeds, but if there are any that contain them the ones so marked are likely to do so.

It is unfortunate that Count Solms was unable to make this investigation when he was studying the British and Italian trunks. In a letter that I received from him dated October 28, 1894, he said:



Cycadeoidea Reichenbachiana (Göpp.) Cap. and Solms.
Dresden Mineralogical and Geological Museum.

"It is to be regretted that at the time I requested it and offered to pay the expenses of transportation and section cutting, permission to investigate the great *Raumeria Reichenbachiana* of the Dresden Museum was not granted me. Now that I am through with this work I would not expend the necessary three or four hundred marks. From the examination of a couple of small splinters broken from it I know, however, that the trunk presents well-preserved areas, and it contains a mass of inflorescences which are certainly wholly included. Geinitz has also sent me the photograph."

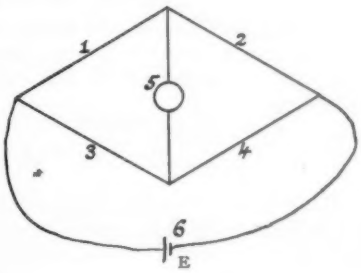
It is greatly to be hoped that Count Solms may be induced to return to this subject and to investigate thoroughly the celebrated Dresden cycad from the standpoint of its internal structure and its botanical affinities.

As the specimen has thus far always been figured inverted, I have undertaken in the figure on the preceding page to show it standing on its base. But having nothing but the reproduction of the photograph sent me by Geinitz, all that can be done is to invert this and reproduce it again. I have already stated that as it stands on the support in the Dresden Museum it leans somewhat on account of the fracture being slightly oblique to the axis. This it is sought to remedy also, and the present figure shows it erect with the scars horizontal and their acute angle downwards, as it undoubtedly grew. As the light was from above in the photograph it is of course from below in this figure, but this mechanical defect is less pronounced than it would be in most cases.

ART. VIII.—*A Comparison of Two Ways of Using the Galvanometer;* by HENRY A. PERKINS.

THERE are a number of instances in laboratory practice where a galvanometer is used to record changes in the resistance of a piece of apparatus such as a bolometer, selenium cell or bismuth spiral where the highest degree of sensitiveness is required, and there is a choice between a Wheatstone Bridge arrangement and a simple series connection. The purpose of this paper is to investigate the relative delicacy of the two methods.

In using the Wheatstone Bridge the variable resistance is introduced in one of the arms, the bridge is balanced and the galvanometer then deflects when the variable arm changes.



In order to calculate the current that will flow through the galvanometer, we apply Kirchhoff's laws, and assume the various resistances equal to r_1, r_2, r_3, r_4, r_5 and r_6, where r_6 is the resistance of the battery, r_5 that of the galvanometer and the others represent the arms of the bridge, r_1 being the variable resistance.

In calculating the galvanometer current we shall make use of the following six equations:

$$(1)\ C_1 = C_2 + C_5$$
$$(2)\ C_3 = C_4 - C_5$$
$$(3)\ C = C_2 + C_4$$
$$(4)\ E = Cr_6 + C_1 r_1 + C_3 r_3$$
$$(5)\ O = C_1 r_1 - C_2 r_2 + C_5 r_5$$
$$(6)\ O = C_3 r_3 - C_4 r_4 - C_5 r_5$$

Combining and assembling the coefficients we obtain

$$C_2(r_1 + r_2 + r_6) + C_4 r_6 + r_1 r_6 = E$$
$$C_2 r_1 - C_4 r_3 + C_5 (r_1 + r_3 + r_5) = O$$
$$C_3 r_3 - C_1 r_4 - C_5 r_5 = O$$

Solving for C_5 by determinants

$$C_5 = \frac{E(r_3 r_2 - r_1 r_4)}{\sum_1^6 r_a r_b r_c - r_1 r_2 r_5 - r_1 r_3 r_6 - r_2 r_4 r_6 - r_3 r_4 r_5}$$

Since r_1 is the variable branch $\frac{dC_5}{dr_1}$ is the measure of the sensitiveness of the arrangement. This differential reduces to

$$-E/\{2r_1r_5+2r_5r_1+r_5r_6+r_5r_6+r_1r_2+r_1r_4+r_1^2+(r_1^2r_6+r_1r_5r_6+r_1^2r_4+r_1r_4r_5)/r_3+(r_3r_5r_6+r_1r_3r_5+r_1r_5r_6)/r_4\}$$

when r_2 has been eliminated by the relation $r_1r_4=r_2r_3$ which is true when the bridge is balanced.

In this equation r_3 and r_4 are independent variables, and it is now essential to find how they should be adjusted to render $\frac{dC_5}{dr_1}$ a maximum. Assuming r_3 constant and differentiating the above coefficient with respect to r_4 and setting it equal to O we obtain a value of r_4 which must be substituted in $\frac{dC_5}{dr_1}$ and the result again differentiated with respect to the one remaining variable, r_3. Finally solving for r_3 and making use of $r_1r_4=r_2r_3$ and the value already obtained for r_4 we have r_2, r_3 and r_4 in terms of the constants r_1 r_5 and r_6. These values are

$$r_2=\sqrt{\frac{(r_1+r_6)\,r_5r_1}{r_1+r_5}} \qquad r_3=\sqrt{\frac{(r_1+r_5)\,r_1r_6}{r_1+r_6}} \qquad r_4=\sqrt{r_5r_6}^{*}$$

We are uow in a condition to evaluate the sensitiveness of the bridge method by substituting the values of r_2 r_3 r_4 in the coefficient of sensitiveness, reducing it to

$$\frac{dC_5}{dr_1}=\frac{-E}{r_1\{2r_5+2r_5^{\frac{1}{2}}\sqrt{(r_1+r_5)}+r_1\}}=S_1$$

where r_6 has been set equal to O, as in either method considered it will be small compared to the other resistances, and if it is retained the above expression is too unwieldy for ready comparison with that which follows.

The second case is much simpler. Here the battery, variable resistance and galvanometer are arranged in series. Assuming here also that the battery resistance is negligible, and also using the same E.M.F. we have

$$C=\frac{E}{r_1+r_5} \text{ and } \frac{dC}{dr_1}=-\frac{E}{(r_1+r_5)^2}=S_2.$$

* Heavyside obtained almost the same results in the fourth paper, Vol. I. Electrical papers, but his value for r_2 is clearly wrong. It should read $\sqrt{\frac{gx(x+f)}{g+x}}$ instead of $\sqrt{\frac{gx(g+f)}{g+x}}$, as can be readily shown by applying the bridge formula to the values of r_3 and r_4 and solving for r_2. Moreover, the value of the differential coefficient $\frac{dC_5}{dr_1}$ was not given, as his method was essentially different from the one just outlined, so his paper was of little assistance.

To compare S_1 and S_2, the most obvious method is to find what conditions render them equal. Setting $S_1 = S_2$ we have $r_s^3 - 4r_1^2 r_s - 4r_1^3 = 0$. The solution of this cubic gives $r_s = 2{\cdot}4\, r_1$, approximately. A further comparison indicates that if the galvanometer resistance is less than 2·4 times that of the cell, the series arrangement is best, although when the galvanometer resistance is zero they are again equal. All values of r_s greater than $2{\cdot}4\, r_1$ give S_1 greater than S_2, and when $r_s = 6r_1$ the bridge method is twice as sensitive.

The following table gives an approximate idea of the relative value of the methods. E is assumed = 100 and $r_1 = 1$. The values are given to the nearest integer.

r_s	S_2	S_1
0	100	100
r_1	25	17
$2r_1$	11	10
$3r_1$	6	7
$4r_1$	4	6
$5r_1$	3	5
$6r_1$	2	4
$7r_1$	1·6	3·4

Another aspect of the problem arises when a certain maximum current through the variable resistance is admissible. Let this current = K. Then in case of the bridge method $K = \frac{E}{r_1 + r_2}$ substituting for E in S_1 we have $S_1 = \frac{2K}{3r_1 + 4r_s}$ very nearly. In order to obtain this simple value it was assumed that in all cases where the current through r_1 arm of the bridge is limited, r_1 will be considerably smaller than r_s; and even if r_1 is half as large as r_s, the error is still very small.

Now S_2 under these conditions $= \frac{K}{r_s + r_1}$ hence it is clear that the series method is always best when the current in r_1 must not rise above K.

One more case remains; when the allowable current through the galvanometer is less than that allowed through the variable resistance. In this case S_1 becomes equal to S_2 when $\frac{K'}{K} = \frac{2(r_s + r_1)}{4r_s + 3r_1}$ when K′ is the maximum current allowed through the galvanometer. If $\frac{K'}{K}$ is smaller than this, the bridge method is clearly best. When K′ is very small indeed as compared to K this method is vastly more sensitive than the other.

Trinity College, May, 1904.

Art. IX.—*Further Work with the Rotating Cathode;* by H. E. Medway.

[Contributions from the Kent Chemical Laboratory of Yale University.—CXXVIII.]

It has been shown in a previous article* that metals may be precipitated electrolytically, with great economy of time and with much exactness, by the use of a rapidly rotating cathode. The apparatus employed consists of a platinum crucible fastened to the vertical shaft of a small electric motor and dipping into the solution to be electrolyzed. A current from a series of storage batteries is passed through the solution between a platinum anode and the crucible, which serves as the cathode, while in rapid rotation; it being found that under these conditions a high density of current may be used with a consequent shortening of time over that required for complete deposition with a stationary cathode.

In the article referred to, attention is called to the rapid determination of copper, silver and nickel electrolytically. It is the purpose of the present article to give results, obtained in the same way, in a study of the conditions adapted to the use of the apparatus upon solutions in common use in the ordinary process of electrolysis between stationary electrodes, and in some cases studied by Exner† with reference to the application of the stirring anode and ordinary cathode to similar rapid precipitations.

Cadmium.

Cadmium sulphate, approximately 0·2 grm., was dissolved in 50 cm³ of water, 10 drops of dilute sulphuric acid added to give conductivity and the solution was electrolyzed, while the crucible, serving as the cathode, was rotating at a rate of 650–700 revolutions a minute. It was noticed that a perceptible solvent action of the acid takes place upon the deposit of cadmium in the short time necessarily taken to remove the crucible from the liquid. Therefore, in order to avoid siphoning, dilute ammonia was added drop by drop after the metal had been all deposited and while the current still passed, until the solution was faintly alkaline.

That this procedure proves satisfactory, the following results will show:

*Gooch and Medway: This Jour., xv, 320, 1903.
†Jour. Am. Chem. Soc., xxv, 896.

Cadmium taken grm.	Cadmium found grm.	Error grm.	Current Amp.	N. D. 100.	Time. min.
0·1088	0·1083	−0·0005	2	6·6	15
0·1088	0·1085	−0·0003	2	6·6	15
0·1088	0·1092	+0·0004	1·5	5·	15
0·1088	0·1090	+0·0002	2	6·6	15
0·1088	0·1093	+0·0005	1·5	5·	12
0·1088	0·1093	+0·0005	2	6·6	10
0·1088	0·1087	−0·0001	2	6·6	10

Tin.

For the purpose of trying the electrolytic deposition of tin, a solution of stannous ammonium chloride was prepared of about 20 cm³ volume. To this was added a cold saturated solution of ammonium oxalate amounting to 100 cm³. The electrolysis then proceeded in the usual way.

Results are below:

	Tin taken grm.	Tin found grm.	Error grm.	Current Amp.	N. D. 100.	Time. min.
1)	0·0804	0·0802	−0·0002	2·5	8·3	20
2)	0·0804	0·0800	−0·0004	2	6·6	20
3)	0·1607	0·1610	+0·0003	2·5	8·3	20
4)	0·1607	0·1603	−0·0004	2·5	8·3	20
5)	0·1607	0·1607	±0·0000	3·5	11·6	15

An alkaline oxalate was also used in the case of zinc—the next metal whose precipitation was attempted, but it was found expedient to use potassium oxalate instead of ammonium oxalate, since the presence of ammonium salts appeared to retard the complete deposition of the metal. Therefore, the following procedure was adopted: The zinc salt—preferably the sulphate—was dissolved in 50 cm³ of water and 4 grms. of potassium oxalate were added. The solution was then submitted to electrolysis.

The results follow:

	Zinc taken grm.	Zinc found grm.	Error grm.	Current Amp.	N. D. 100.	Time. min.
1)	0·0553	0·0556	+0·0003	2·5	8·3	25
2)	0·0553	0·0553	±0·0000	2·5	8·3	25
3)	0·0553	0·0552	−0·0001	2·5	8·3	25
4)	0·0993	0·0995	+0·0002	2·5	8·3	30
5)	0·0993	0·0994	+0·0001	2·	6·6	25
6)	0·0993	0·0991	−0·0002	2·	6·6	25

In the usual method of electrolysis with stationary electrodes, it has been found that, when the attempt is made to remove the zinc from the platinum upon which it has been deposited, there is a coating of platinum black, some of the zinc presumably having amalgamated with the platinum. Only by dissolving the zinc, heating the crucible to redness and finally making another application of acid can this black coating be conveniently removed, there being a loss of platinum due to this removal. In order to avoid this formation it has been found necessary to coat the platinum with copper and deposit the zinc upon this. The zinc and copper may then be easily removed together by acid.

In depositing the zinc upon a rotating cathode it was found to be unnecessary to coat the platinum with copper, since the zinc could be removed without any appearance of platinum black, thus avoiding the second treatment by acid, with the attendant loss of platinum.

Gold.

The apparatus was next applied to the determination of gold. A solution of auric chloride was made of 25 cm³ volume. Potassium cyanide was then added in considerable excess and about 30 drops of strong ammonia. The electrolysis was carried on in the usual manner.

The results are given below:

Gold taken grm.	Gold found grm.	Error grm.	Current Amp.	N. D. 100.	Time. min.
0·0695	0·0694	−0·0001	2·	6·6	30
0·0695	0·0696	+0·0001	2·	6·6	30
0·0598	0·0598	±0·0000	0·5	1·8	30
0·0598	0·0598	±0·0000	0·5	1·8	30
0·0598	0·05975	−0·00005	1·	3·3	25

No attempt was made to find the minimum time required for these depositions.

Art. X.—*On the Transverse Vibrations of Helical Springs;* by Howard L. Bronson.

It has been known for a long time that the pitch of a stretched india-rubber cord rises very little, if at all, when its length is increased by stretching. This peculiarity has been recently investigated by T. J. Baker* and by Viktor v. Lang.† Both found that the apparent constancy in pitch is in some way related to the fact that the length and tension are linearly related through a considerable range.

Now if a linear relation between length and tension is the only requisite for constancy of pitch, then certainly a helical spring ought also to have a constant pitch for a considerable change in length. This consideration, together with the fact that a metal spring ought to be more uniform in its behavior than a rubber cord, were the two things which suggested this study of helical springs.

Apparatus.

The first thing necessary for the investigation was to find suitable springs, which should have considerable range in size and stiffness. Seven springs were made of brass wire which seemed to have sufficient regularity and the desired range of size. The following table gives for each spring the diameter of wire used, the diameter of the mandrel on which it was wound, its mass, and L′, the approximate percentage increase in length for an increase in tension of ten grams.

Table I.

	Diam. of Wire.	Diam. of Mandrel.	Mass.	L′.
Spring 1	0·29 mm.	1·80 mm.	1·283 gr.	13
Spring 2	0·29	3·18	1·298	50
Spring 3	0·42	3·18	2·210	9
Spring 4	0·46	3·18	3·769	5
Spring 5	0·46	5·18	6·058	20
Spring 6	0·91	5·94	24·750	1
Spring 7	0·46	5·94	6·536	30

The relation between the length and tension was obtained with the spring hung in a vertical position, the lengths being read directly from a mirror scale.

The accurate determination of the frequency was the most difficult part of the work, but very consistent results were finally obtained by the use of a chronograph. The time was furnished by a clock with a seconds pendulum, which was arranged to make one contact every complete vibration. These two-second intervals were very uniform, and a comparison with the Yale

* Phil. Mag., vol. xlix. † Wied. Ann., vol. lxviii.

Observatory clock showed that the rate of the clock used was entirely negligible for the purpose in hand.

Figures 1, 2 and 3 show the arrangement of the apparatus for holding the spring and starting the vibrations. MN, fig. 1, is the base about 40 inches long and $1\frac{1}{4}$ inches thick. On the

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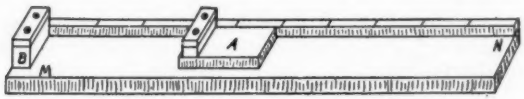

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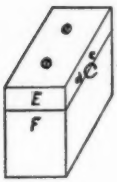

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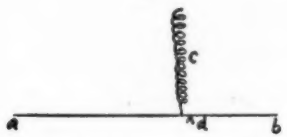


back of this is a metre scale, from which the lengths of the spring were read directly. One end of the spring was clamped to the fixed block B, the other to the movable block A.

It was found quite difficult to clamp the ends of the springs in any manner which did not have an appreciable effect on the frequency. The method finally adopted is shown in fig. 2. The last turn of the spring was drawn close up to the block by means of two fine wires fastened at *c* and *d*, which are the extremities of its horizontal diameter. These two wires were then clamped between the blocks E and F, and held the spring very firmly, yet with very little constraint.

A fine wire fastened to the center of the spring made contact with a mercury cup at each vibration. The chronograph was adjusted delicately enough to record signals with frequency as high as thirty-five per second.

In order to have uniformity in the amplitude of the vibrations, it was found convenient to use an apparatus of which fig. 3 is a diagrammatical sketch. *a b* is a wooden arm about 9 inches long pivoted at *a*; *d* is a stop which can be adjusted so that the end *b* will start the spring vibrating with the desired amplitude; the spring *c* is strong enough to release the spring without interfering with its vibration.

Observations and Calculations.

The method of making the observations in the case of springs 1, 2 and 6 was as follows:—The relation between the length and tension was determined, the tension being first increased from zero until the increase in length was no longer propor-

tional to the increase in tension, and then being decreased to zero again. Immediately after this the relation between the length and frequency was determined, starting with as short a length as possible and increasing it up to the maximum length obtained above and then decreasing it again as far as possible. The relation between the length and tension was then again obtained as in the first place. A complete set of observations for spring 1 is given in Table II.

TABLE II.

T.	Out L.	In L.	L.	Out n.	In n.	T.	Out L.	In L.
0	9·32	9·33	10	14·80	14·69	0	9·34	9·34
10	10·02	10·08	11	18·16	18·01	10	10·07	10·10
20	11·40	11·48	12	20·43	20·31	20	11·46	11·49
30	12·81	12·90	13	22·13	22·04	30	12·88	12·94
40	14·23	14·32	14	23·45	23·41	40	14·28	14·35
50	15·68	15·76	15	24·62	24·50	50	15·73	15·80
60	17·13	17·18	16	25·49	25·47	60	17·16	17·21
70	18·60		17	26·26	26·22	70	18·64	
			18	26·93				

Here T is the tension measured in grams, L is the length measured in cm., and n is the number of vibration per second. "Out" means increasing, and "In" decreasing tension or length.

The first set of values between length and tension was preliminary, taken to find the point at which the relation between the length and tension ceased to be linear. This stretching of the spring also served to remove certain very slight irregularities, as was evident when several length-tension sets were taken in succession, in which case the behavior of the spring was practically the same in all sets except the first. Therefore in making the plots and calculations the mean of the length-frequency and final length-tension sets were used, and in general only these values have been recorded in the tables.

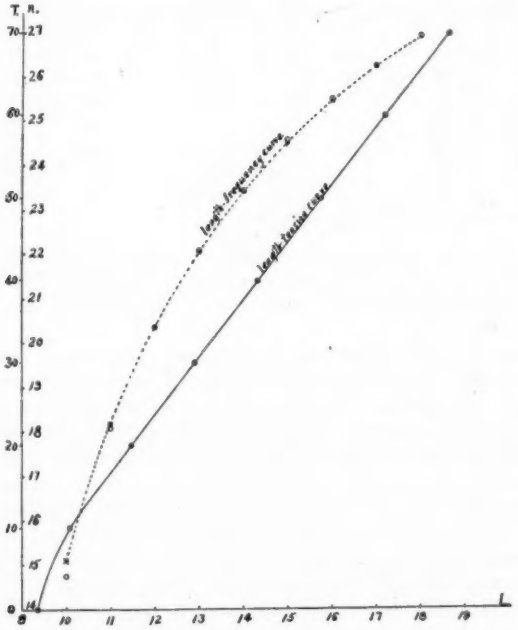
Table III gives the mean values of L and n from Table II, also the calculated values of n and the difference between the observed and calculated values.

TABLE III. (Spring 1.)

T.	L.	L.	Observed n.	Calculated n.	Difference.
0	9·34	10	14·74	15·08	— 0·34
10	10·09	11	18·08	18·16	— 0·08
20	11·47	12	20·37	20·37	0·00
30	12·91	13	22·08	22·06	+ 0·02
40	14·32	14	23·43	23·41	+ 0.02
50	15·76	15	24·56	24·52	+ 0·04
60	17·19	16	25·48	25·45	+ 0·03
70	16·64	17	26·24	26·24	0·00
		18	26·93	26·92	+ 0·01

Figure 4 gives the length-tension and length-frequency curves plotted from the values given in Table III. The full and dotted lines represent respectively the observed and calculated curves; the observed points are surrounded by circles, and the calculated points are indicated by crosses. In case the observed and calculated curves agree too closely to show both, the calculated curve will be given, and the observed points indicated by circles.

4



It is evident from the plot that the relation between the length and tension is practically linear through nearly the entire range used. This relation is most simply expressed by the equation

$$T = mL + x \tag{1}$$

where m is the slope of the line, and x is the point at which, if continued, it would intersect the T axis.

In order to find the relation between length and frequency, it seemed most natural to take the usual expression for a vibrating string, which for the present purpose is most conveniently written in the form

$$(2) \qquad n = \tfrac{1}{2}\sqrt{\frac{T}{L}\frac{g}{M}}$$

where M is the total mass of the spring. If T is now eliminated between (1) and (2) the relation between L and n takes the form

$$(3) \qquad n = \tfrac{1}{2}\sqrt{\frac{mL + x}{L}\frac{g}{M}}.$$

The values of n calculated by this formula differed considerably from the observed values, as might have been expected, for in the first place the values used for T entirely ignored the weight of the spring and were therefore always too small, and in the second place the length of the spring was taken as the distance between the two blocks A and B (fig. 1), which was evidently somewhat greater than the true vibrating length. In order to avoid these two difficulties, another constant was added to equation (3). Two equations similar to (3), but with this added constant, were then used to solve for the unknown quantities x' and y.

$$(4) \quad \begin{cases} n_1 = \tfrac{1}{2}\sqrt{\dfrac{mL_1 + x'}{L_1 + y}\dfrac{g}{M}} \\ n_2 = \tfrac{1}{2}\sqrt{\dfrac{mL_2 + x'}{L_2 + y}\dfrac{g}{M}}. \end{cases}$$

Solving for y and x' gives

$$(5) \qquad y = \frac{N_1 - N_2 + K_2 - K_1}{4n_1^2 - 4n_2^2}$$

$$(6) \qquad x' = \frac{M}{g}(K_1 + 4n_1^2 y - N_1)$$

where $N_1 = \dfrac{mg}{M}L_1$; $N_2 = \dfrac{mg}{M}L_2$; $K_1 = 4n_1^2 L_1$; $K_2 = 4n_2^2 L_2$.

The value of m is always taken as the slope of the straight part of the length-tension curve; L_1, n_1, L_2 and n_2 are corresponding values of L and n taken from the length-frequency curve. The values of the constants for spring 1 are as follows:

M = 1·2834	m = 7·00
L_1 = 12	n_1 = 20·37
L_2 = 17	n_2 = 26·24

Substituting these values in (5) and (6) gives

$$y = -\ 0{\cdot}1714$$
$$x' = -58{\cdot}29$$

and putting these values in (4) gives the equation in its final form

$$(7) \qquad n = \tfrac{1}{2}\sqrt{\frac{L-8\cdot328}{L-0\cdot1714} \cdot \frac{7\cdot00\times980}{1\cdot2834}}$$

The values of n calculated by this formula are given in Table III and are plotted in fig. 4.

The results obtained with springs 2 and 6 were so similar to those obtained with 1 that it is unnecessary to give them here.

In order to study the behavior of a spring beyond the point where the length and tension were linearly related, it was necessary to modify the method of making the observations. The series with decreasing lengths was in all cases omitted, and several hours were left between successive sets of observations, so that the spring might recover as far as possible its original condition. Table IV and fig. 5 give the results for spring 3 obtained in this way.

TABLE IV. (Spring 3.)

T.	L.	L.	Observed n.	Calculated n.	Differences.
0	7·74	8	12·45	13·05	−0·60
10	8·62	9	16·89	17·09	−0·20
20	9·51	10	19·71	19·71	−0·00
30	10·41	11	21·62	21·61	+0·01
40	11·30	12	23·05	23·06	−0·01
50	12·20	13	24·21	24·22	−0·01
60	13·10	14	25·15	25·16	−0·01
70	14·00	15	25·96	25·95	+0·01
80	14·91	16	26·62	26·62	−0·00
90	15.84	17	27·16	27·19	−0·03
100	16·75	18	27·64	27·69	−0·05
110	17·69	19	28·07	28·13	−0·06
120	18·62	20	28·41	28·52	−0·11
130	19·59	21	28·73	28·87	−0·14
140	20·50	22	28·98	29·18	−0·20
150	21·45	23	39·19	29·46	−0·27
		24	29·30	29·71	−0·41

Data used in the calculations for spring 3:

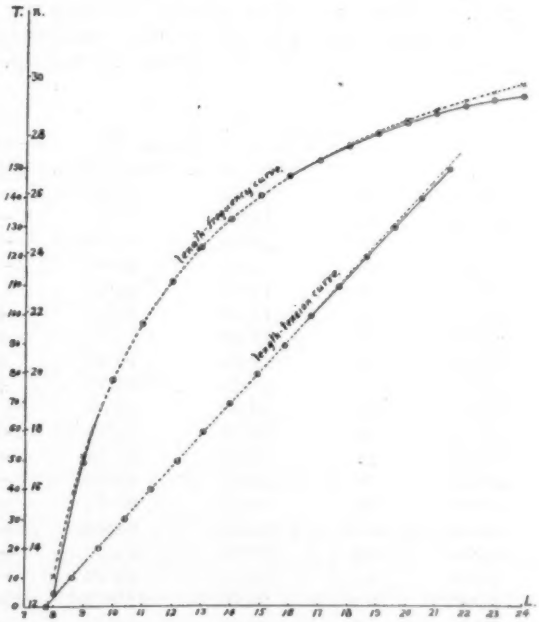
$M = 2\cdot210$ $\qquad m = 11\cdot04$
$L_1 = 10$ $\qquad n_1 = 19\cdot71$
$L_2 = 16$ $\qquad n_2 = 26\cdot62$
$y = -0\cdot333$ $\qquad x' = -76\cdot55$

In fig. 5 it is seen that the difference between the observed and calculated values of n becomes greater the further the length-tension curve departs from a straight line. This is just what would be expected, if springs obey the same law as vibra-

ting strings, in fact the equation requires that the percentage difference between the observed and calculated values of the frequency for a given length shall be twice the percentage difference between the observed and calculated values of the tension for the same length. If careful measurements are made on the plot, this will be found to be approximately true.

It is also seen in fig. 5 that n is apparently approaching a maximum value. This fact made it seem desirable to carry the curves considerably further beyond the point where the length and tension are linearly related. Since for this case only a single set of observations could be made with one spring, on account of the permanent distortion produced, the most practicable method seemed to be to make two springs as nearly alike as possible. This was accomplished quite satisfactorily by cutting into two parts a very uniform spring and then adjusting the two parts until they had as nearly as possible the same mass, length and rate of extension.

5



Springs 4 and 5 were treated in this way, but the results were so similar that only those for 4 will be given. Table V shows how similar were the two parts into which spring 4 was made.

TABLE V.

T.	4*a* L.	4*b*.
0	12·18	12·18
20	13·63	13·63
40	15·10	15·08
60	16·56	16·55
80	18·03	18·03
100	19·53	19·51

Mass of $4a = 3{\cdot}769$
" $4b = 3{\cdot}783$

Springs 4*a* and 4*b* are certainly similar enough for the purposes of this investigation. The relation between the length and tension was determined with 4*b* and the relation between the length and frequency with 4*a*. Table VI and fig. 6 give these results.

TABLE VI.

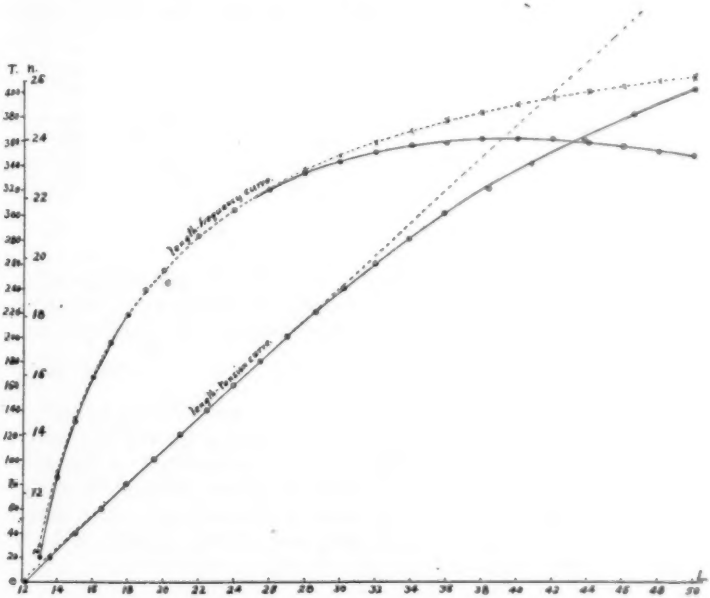
Spring 4*b*		Spring 4*a*			
T.	L.	L.	Observed *n*.	Calculated *n*.	Difference.
0	12·18	13	9·82	10·21	−0·39
20	13·63	14	12·56	12·72	−0·16
40	15·08	15	14·45	14·55	−1·10
60	16·55	16	15·92	15·96	−0·04
80	18·03	17	17·11	17·11	0·00
100	19·51	18	18·09	18·07	+0·02
120	21·00	19	18·91	18·88	+0·03
140	22·50	20	19·61	19·58	+0·03
160	24·00	22	20·75	20·72	+0·03
180	25·51	24	21·63	21·63	0·00
200	27·05	26	22·31	22·36	−0·05
220	28·66	28	22·85	22·98	−0·13
240	30·23	30	23·26	23·48	−0·22
260	32·03	32	23·58	23·92	−0·34
280	33·90	34	23·81	24·30	−0·49
300	35·90	36	23·88	24·63	−0·75
320	38·38	38	24·02	24·92	−0·90
340	40·83	40	24·02	25·18	−1·16
360	43·80	42	24·01	25·42	−1·41
380	46·60	44	23·88	25·63	−1·75
400	50·00	46	23·76	25·81	−2·05
		48	23·60	25·99	−2·39
		50	23·44	26·14	−2·70

Data used in the calculations for spring 4*a*:

$M = 3{\cdot}769$ $\qquad m = 13{\cdot}50$
$L_1 = 17$ $\qquad n_1 = 17{\cdot}11$
$L_2 = 24$ $\qquad n_2 = 21{\cdot}63$
$y = -0{\cdot}596$ $\qquad x' = -155{\cdot}6$

The length-frequency curve for spring 4*a* differs from the others thus far studied in that the frequency has passed beyond the maximum point. If the frequency of the vibrations of the springs, when stretched beyond the elastic limit, obeys the same law as before, then along the flat maximum of the curve where

6



n is nearly constant, the ratio of T to L ought also to be nearly constant. An examination of fig. 6 gives the following values for n and $\frac{T}{L}$ for a few values of L along this part of the curve.

TABLE VII.

From Fig. 6.

L.	n.	$\frac{T}{L}$
34	23·81	8·26
36	23·88	8·36
38	24·02	8·34
40	24·02	8·32
42	24·01	8·29
44	23·88	8·22

The above table makes it seem very probable that the frequency of vibration of a spring would be approximately constant through a long range of lengths, if it could be so made that $\frac{T}{L}$ would be constant along the linear part of the length-tension curve, or in other words if x in the equation $T=m\,L+x$ could be made zero. Spring 7 was made with this end in view. It differed from all the other springs made by having its turns

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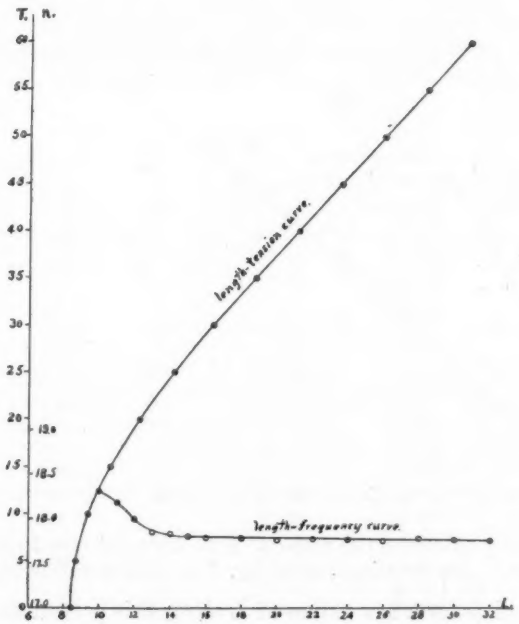

wound so tightly together that they did not become entirely separated until loaded with about 30 grams. The winding of this spring was more difficult than that of the others, and it was not nearly so uniform, but its frequency was very constant, differing only by one-twentieth of a vibration per second when its length was increased from 15 cm. to 32 cm.

The results for spring 7 are given in Table VIII, and the values are plotted in fig. 7.

TABLE VIII. (Spring 7.)

T.	L.	$\frac{T+x}{L}$	L.	n.
0	8·43		10	9·32
5	8·69		11	9·18
10	9·37		12	9·01
15	10·63		13	8·86
20	12·31		14	8·84
25	14·22	1·990	15	8·81
30	16·42	2·028	16	8·79
35	18·80	2·037	18	8·78
40	21·23	2·040	20	8·77
45	23·66	2·041	22	8·78
50	26·09	2·043	24	8·77
55	28·51	2·045	26	8·76
60	30·90	2·048	28	8·78
			30	8·76
			32	8·76

In calculating the ratio of T to L, a small correction x equal to about one half the weight of the spring was added to T. As was expected, the frequency was very constant through the same range that $\frac{T+x}{L}$ was constant.

Sufficient evidence, I think, has been furnished to show that vibrating helical springs obey the same law as vibrating strings through a considerable range of length and tension. It would seem of interest now to examine the behavior of india-rubber cords under conditions as similar as possible to those experienced by the springs and to compare their behavior. For this pur-

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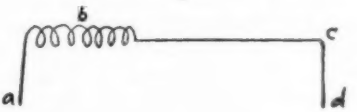

pose two samples of as pure rubber as could be obtained were used; one a rubber tube of about 4·68 mm. external and 3·06 mm. internal diameter, the other a rubber cord of square cross section, 1·16 mm. on a side.

The observations were taken in the same way as in the case of the springs, except that a slight modification had to be made in order to get electrical connection. In the case of the rubber tube a ∪-shaped piece of wire was hung on its center and held fast with rubber cement. The vibrations of the tube caused the two ends of the wire to dip into two mercury cups. In the

case of the rubber cord the contact was made by a very fine wire bent as shown in fig. 8.

The end *a* was firmly fastened. The point *c* was fastened with rubber cement to the rubber cord, the vibration of which caused the point *d* to dip into a mercury cup. The spring *b* was used to increase the flexibility of the wire until it had practically no period of vibration of its own. While there are some objections to this method of making the contact, the weight of the wire was so small and the adjustments made with such care, that the results are sufficiently satisfactory for com-

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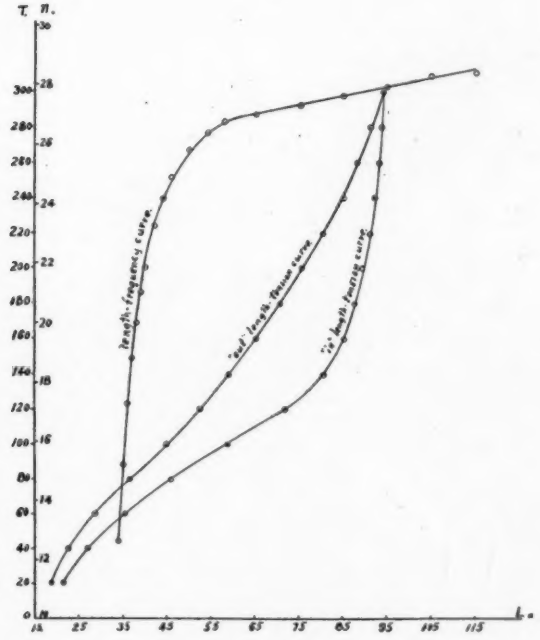

parison with those of the springs. In all cases with the rubber the successive observations were made as rapidly as possible, in order that time effects might be reduced to a minimum. Between the length-frequency observations and the length-tension observations time was allowed to elapse until the rubber practically recovered its original length.

The tube and the cord gave very similar results; those for the cord are given in Table IX and fig. 9.

TABLE IX. (Rubber cord.)

L.	n.	T.	Out L.	In L.
34	12·60	0	16·20	17·6
35	15·18	20	18·74	21·3
36	17·25	40	22·62	27·0
37	18·78	60	28·7	35·4
38	19·95	80	36·6	46.0
39	20·98	100	44·9	58·8
40	21·83	120	52·4	71·8
42	23·23	140	59·0	80·4
44	24·15	160	65·2	85·1
46	24·88	180	70·5	87·4
50	25·80	200	75·6	89·1
54	26·35	220	80·3	90·9
58	26·73	240	84·9	92·0
65	27·00	260	88·0	92·9
75	27·28	280	91·0	93·6
85	27·60	300	93·8	
95	27·90			
105	28·25			
115	28·38			

The similarity of the curves obtained with the rubber cord and those obtained with the springs is very noticeable. This is especially true for the first part of the length-tension curves in figs. 7 and 9, which would seem to indicate that the rubber is in a state of internal stress, even when there is no external tension, which was certainly true in the case of spring 7. Fig. 9 also shows what a very important effect the previous condition of the rubber has upon the relation between the length and tension. The condition of the rubber is also to a considerable degree dependent upon time and temperature, which explains why it is so difficult to make satisfactory measurements with it.

Although there are some irregularities in the curves given, especially those for the rubber, and for the springs when the tension was so small that the effect of the restraint of the ends was considerable, yet the following conclusions seem to be justified:

1. In the study of the transverse vibrations of helical springs and india-rubber cords one radical difference is noticed between them and ordinary strings, namely the fact that their length varies greatly with the tension instead of remaining very approximately constant.

2. While the frequency of the vibrations of the springs and rubber cord is expressed by the formula usually employed in the case of ordinary strings, yet the results obtained are very different on account of the great variations of the length with the tension.

3. The approximate constancy in pitch for a considerable change in length, which has been so often noticed with india-rubber cords, is also observed in a still more marked degree in the case of helical springs.

4. This approximate constancy of pitch for a considerable change in the length of both the rubber cords and the springs is due to the fact that during the change, the length and tension have remained nearly proportional.

In conclusion I desire to express my thanks to Professor A. W. Wright for suggesting the subject and furnishing the apparatus and assistance necessary in carrying on the investigation. I wish also to thank Mr. O. C. Lester for his assistance in performing the experimental work.

Sloane Physical Laboratory,
Yale University, May 1, 1904.

Art. XI.—*A new Type of Calcite from the Joplin Mining District;* by Douglas B. Sterrett.

During the past spring an interesting type of calcite crystals has been added to those already produced by the prolific Joplin region. The crystals are all twins and show a uniformity of a development unusual for the species. They were obtained from a small cave discovered in the Maybell Mine at North Empire, Kansas. According to Mr. W. L. Bachtell, who has had charge of the removal of the crystals, the cave was opened at a depth of 135 feet while blasting in the chert. It was 50 feet long, 4 to 8 feet high and 6 to 12 feet wide. Specimens were sent by Mr. Bachtell to Prof. E. S. Dana at New Haven, and it is at his suggestion that this brief study of their forms and development has been undertaken. These specimens, with others loaned to the writer by Mr. George L. English of New York, and one from the Brush collection, were used in the preparation of this article. Mr. English described this new occurrence in a lecture before the New York Mineralogical club on March 15th. Since his lecture was not published, it has been deemed advisable to give a brief description of the occurrence and of some characteristic specimens.

Most of the crystals are very large. Mr. English states that according to the information that has come to him, probably less than two hundred were obtained from the cave, and only some dozen or so were of a size suitable for cabinet drawer specimens. One of the larger crystals, now in the Yale College collection, measures 39·5^{cm} along the reëntrant angle, 19^{cm} in thickness and 30^{cm} high, according to the orientation chosen in fig. 1. This crystal weighs 62 pounds and is very well developed for one of such size. Probably the smallest is the one shown in fig. 2, which is only 4·7^{cm} in greatest length. One remarkable feature which most of these crystals possess is a delicate amethystine or lilac color, much resembling that of the pale-colored kunzite. The color is not uniformly distributed through the crystals, but is confined chiefly to the outer parts and appears to lie in a plane parallel to the crystal faces, especially the *e* face. Owing to their form and great beauty of color, they are called the "amethystine twin calcites."

The crystals are twinned on the *e* face $(01\bar{1}2)$, according to a very common law for calcite. In representing them, drawings were made with the twinning plane vertical (as in figs 1 and 2), also with the lower crystal in normal position for a positive form while the upper negative crystal was tilted back into twin position (as in figs. 3, 4 and 5). Measurements were made

on some of the smaller crystals, the quality of which allowed very satisfactory determinations of the following forms:

r $(10\bar{1}1)$	f $(20\bar{2}1)$	t $(21\bar{3}4)$
M $(40\bar{4}1)$	l $(40\bar{4}5)$	C $(61\bar{7}8)$
m $(10\bar{1}0)$	e $(10\bar{1}2)$	

The l face on most of the crystals is so etched as to be difficult to measure. On one small crystal, however, it gave fairly good reflections and an average value was obtained of $m \wedge l = 51° 56'$; theory $51° 43'$. The C faces appeared to be only vicinal growths on r, but when measured gave good reflections and an average value of $C \wedge r = 8° 44\frac{1}{2}'$; theory $8° 46'$.

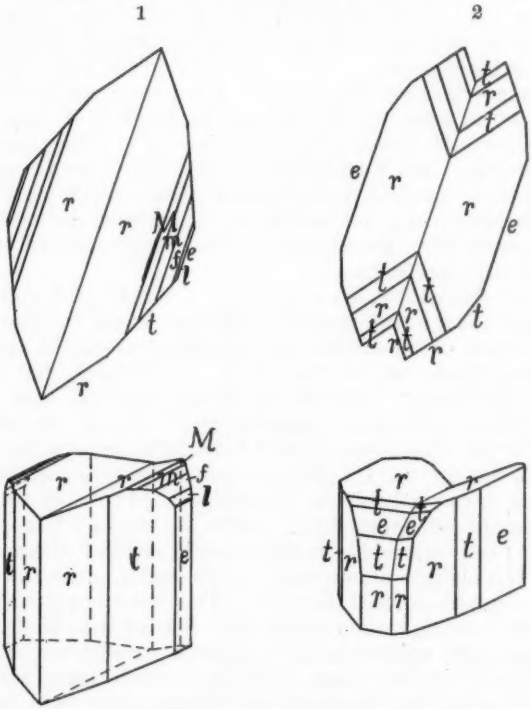

Fig. 1 represents a quite symmetrically developed crystal belonging to the Yale College collection. It was found that a drawing, made in clinographic projection with the twinning plane vertical, gave little idea as to the length along the twinning plane; so orthographic projections were also made to accompany figs. 1 and 2. Fig. 2 shows the development of

a small crystal loaned by Mr. English. It might be considered as made up of two separate individuals grown together in twin position. On each the zone *r*, *t* and *e* appears three times. There was a very small development of the faces of the zone *r*, *M*, *m* – – – and *e* in their proper positions, though these are not shown in the figure. Fig. 3 represents an ideal

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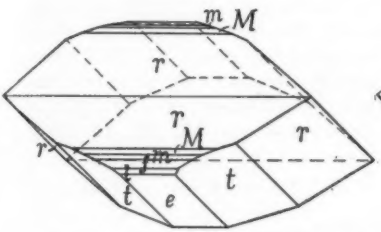

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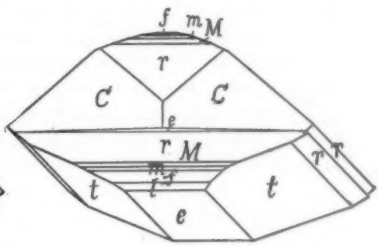

development of a crystal which is given in its natural distortion in fig. 4. The *C* faces were not drawn in fig. 3, since they occur only on one of the twins. As shown in fig. 4, they form an intersection with the twinning plane *e*, which extends above the line of intersection of the twin crystals. This crystal is apparently terminated below by natural *r* faces parallel to those above and forming an obtuse angle. In most of the crystals a natural termination fails, and its place is occupied by cleavage planes developed when the crystals were detached from the rock. On some crystals the *e* face is wanting, in

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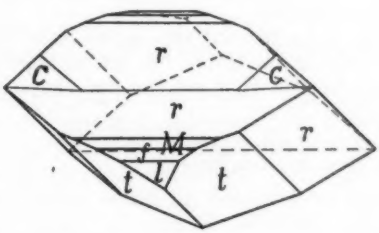

which case *l* has a larger development, as shown in fig. 5. This represents a large specimen in the Brush collection on which the *C* faces appear again only on one of the crystals. In this case they form no intersection with the twinning plane, as in fig. 4, but together with *r* of the upper crystal overlap the lower one, meeting the *r* of the latter beyond the twinning

plane. The occurrence of *C* on only one individual of a twin was observed on four specimens, while on the large crystal described above, *C* occurred on both.

The crystals show a tendency toward a prismatic development parallel to the *e* faces. This was further marked by pits or negative crystals of prismatic form observed on the *e* faces of one crystal. The faces of the negative crystal were parallel to the unit rhombohedrons, and therefore rhombohedral themselves. One crystal, probably from another opening in the same mine, showed the same method of twinning, though this fact was nearly concealed by the development of very large *v* faces nearly covering the reëntrant angle of the twins.

The development of a twin crystal similar to those described above was observed on a single specimen of golden calcite from the Joplin region about two years ago by Mr. English.

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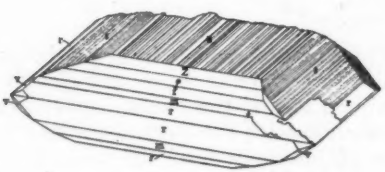


At his request, a drawing of it was prepared by Mr. H. P. Whitlock; Mr. English has kindly allowed a copy of the figure to be inserted here for comparison. The letters represent forms found in Dana's System of Mineralogy. Whether other crystals were found and what was the exact locality for this could not be learned.

In conclusion, acknowledgment is made to Mr. English for generously supplying material for examination, and to Prof. E. S. Dana and Dr. W. E. Ford for assistance in the preparation of this paper.

Sheffield Laboratory of Mineralogy,
Yale University, New Haven.

Art. XII. — *Radium and the Electron Theory;* by John Trowbridge and William Rollins.

The mechanism of electric conduction through metals continues to be one of the greatest mysteries of electricity; and there is no plausible explanation of it unless we accept the theory of electrons. This theory, as is well known, supposes the existence of small bodies called electrons, which move between the molecules of the metals during the passage of an electric current. It has been much developed by Drude.*

The theory seems to bring the electrical conduction in metals into close touch with conduction in gases; for in both cases we suppose a movement of small particles. These particles have a greater free-path in rarified gases than they have between the molecules of a metal, and their action is much modified by the X-rays. This modification is usually attributed to a species of ionization due to a physical connection between the energy emitted by the X-rays and the transformation of energy witnessed in the rarified gas. A Geissler tube, for instance, which will not permit the passage of an electric current, when the degree of exhaustion is beyond the point of breaking down with the electromotive force employed, is made conducting when the X-rays fall upon it.

We mention this fact in order to give a significance to our experiments with radium. This remarkable substance, also, in common with the X-rays can affect by what we call ionization, the conduction of electricity through gases. The X-rays and certain emanations of radium can also pass through thin sheets of metal, especially sheets of aluminium. We are, therefore, for the first time in the history of electricity, in a condition to test the question, whether radiant energy exhibiting light and passing through a metal can affect the passage of a current of electricity.

In this connection one is immediately reminded of Faraday's attempt to discover whether ordinary light is modified in passing through an electrolyte which is submitted to the action of a current of electricity. He thought that there might be a state of tension which could be detected by polarized light; and he therefore passed a beam of polarized light in the direction of the current and also at right angles to this direction. The result of the experiment was negative; absolutely no effect was observed. Faraday's custom of publishing both positive and negative results has its advantages, especially in the early days of a science; and particularly when it shows us

* Ann. der Physik., No. 1, 1900.

the working of a great mind groping in a region not yet submitted to calculation. Lesser minds must, however, use caution in publishing negative results; for due regard must be had for brevity of publication and the limits of experimentation.

Can we not, however, imagine Faraday continuing his efforts to discover some connection between the passage of light through an electrolyte or a conductor and the passage of a current of electricity, if he could penetrate such a conductor by light. In other words, might he not have been tempted, if he had had command of the X-rays or radium, to discover some action of the energy emitted by the new and wonderful manifestations on a current? Apart, however, from such a view of the working of the great physicist's mind, can we not get a foothold in mounting to the heights of the electron theory by endeavoring to show that the X-rays or the emanations from radium do or do not have a discoverable action upon the passage of an electric current, through aluminium for instance?

It must be premised that no mass is ascribed to the electron. Its supposable inertia is due to self-induction, and perhaps it should not be called a body. On this conception it does not seem probable that particles shot off from radium, or ions resulting from the radiation of X-rays, could influence such immaterial bodies. Nevertheless our view of the electron theory might be influenced by proceeding to an actual test, and by looking at the results and limitations of possible experiments. We therefore experimented as follows:

A meter of aluminium wire No. 24 was wound in five turns around a thick sheet of lead which was eight centimeters in length and one centimeter in width. The wire was wound around the longest dimension of this shuttle-like piece of metal, and was insulated from it by thin sheets of vulcanite. The electric current, therefore, passed in one direction along the upper layer of the wire, and in the opposite direction along the lower layer. The lead, intervening between the upper and lower layer, could serve to confine the radiations from suitably placed radium either to the upper or the lower layer of wire. The lead shuttle with its layer of wire was enclosed in a lead cylinder and a specimen of pure radium bromide was enclosed at one end of the layers of wire so that its emanations could sweep along the upper or the lower layer of this wire. A lead diaphragm could be used to shut off the entire effects of the radium from the wires.

The wire was made one branch of a Carey-Foster bridge; a suitable key made it possible to reverse the current through the aluminium wire, and after adjustment the wire was exposed to the radiations from the aluminium under the varying conditions of reversals of current; radiations confined to the lower layer

and afterwards to the upper layer. The bridge was competent to detect a change in resistance of one hundredth-thousandth of an ohm. On account of the difficulty of distinguishing between a heating effect and what may be called an electrodynamic effect, the observations occupied a comparatively short interval of time. No instantaneous effect was observed: a very slight creeping deviation of the galvanometer mirror came after a considerable interval of time, which might have been due to change of temperature. It could not be ascribed with reason to the presence of the radium.

The light from the radium could be seen through a slab of iron an inch thick; yet this manifestation of energy passed through the aluminium without any apparent effect upon the mechanism of the electric current. Should we reason, therefore, from this negative experiment that the theory of the immaterial electron is supported, or that a theory of dissociative effect on gases between each molecule of the metallic conductor under the effect of a current is also negatived: for the radium emanations, like the X-rays, can produce this dissociative effect in the passage of electricity through gases?

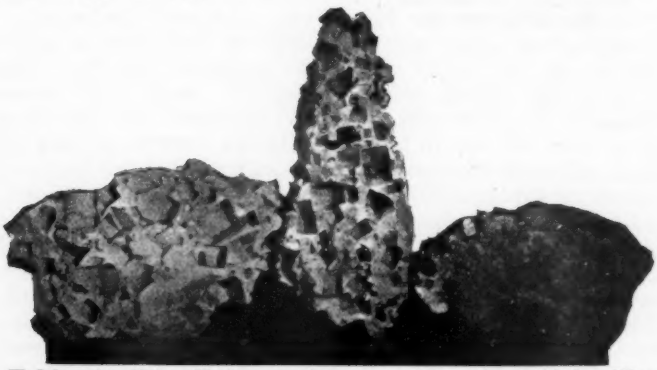
Mr. McKay, graduate student working in this laboratory, has endeavored to detect the effect of the X-rays in changing the apparent resistance of thin films of metals. The effect, if it exists, is extremely small. He, however, is still continuing his work upon this subject.

Jefferson Physical Laboratory,
Harvard University.

ART. XIII.—*Pseudomorphs and Crystal Cavities;* by J. P. ROWE.

SOME of the finest pseudomorphs and crystal cavities the writer has ever seen came to his notice recently from specimens collected near Shoshone, Idaho. The material was collected and sent to the University of Montana by Rev. T. L. Lewis. The natural mineral is pyrite, imbedded crystals; the pseudomorph, limonite; and the matrix, a fairly pure, light colored, quartzite.

Specimens were found showing the unaltered pyrite cubes below imbedded in pure homogeneous quartzite, the pseudomorphs of limonite above in the same material, and still higher the beautiful and perfect cavities, where the pseudomorphs had been dissolved out by the action, probably, of meteoric water. Almost all of these cavities show the delicate striations of the pyrite cubes. The matrix is literally filled with these cavities and presents a regular honeycombed appearance. The size of the cavities range from ·15 of a centimeter in diameter to 2·5 centimeters. However, but few if any of the cavities are perfect cubes. One of the most interesting things about these specimens is, that the distance from the pyrite crystals to the crystal cavities, i. e. including the pseudomorph limonite, in many instances, is not more than five centimeters. In fact, in many cases the pseudomorphs are not more than 1·5 to 2 centimeters from the pyrite crystals.



Taking it all in all the specimens are very beautiful. They show the transition of the pyrite to the limonite as do but very few specimens. They also show that limonite is easily soluble in certain kinds of water. They still show how these cavities might be refilled with quartz or calcite or some other mineral from solution and again give false forms, not true pseudomorphs as in the first instance, but so to all appearances.

University of Montana, Missoula, April 29, 1904.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Emanium.*—F. Giesel has obtained from pitchblende an earth consisting chiefly of lanthanum which shows strong radio-active properties. He finds that the behavior of the material is different from that of radium, and believes that he has obtained a new element which he calls emanium and which he hopes to separate from lanthanum. The striking characteristic of this material appears to be an emanation given off by it. When air is blown through a flask containing preparations of the substance enclosed in paper capsules, and the air issues from a tube against a blende screen, a brilliant illumination is produced, and scintillations can be observed, even with the naked eye. The "sparks" are more distinct and larger than those produced by radium or polonium, and hence the material is more effective than these for use in the spinthariscope.—*Berichte*, xxxvii, 1696. H. L. W.

2. *Radio-activity and Matter.*—This topic has been recently discussed by Professor Winkler, who is perhaps the most prominent inorganic chemist in Germany. The great importance of the recent discoveries connected with radio-active substances is admitted, but the author doubts that the existence of new elements in this connection has been satisfactorily demonstrated. He is inclined to consider radio-activity as a purely physical process, which, like magnetism, may act upon matter without affecting its chemical nature. He points out that radium, which was discovered nearly six years ago, is but slightly known in its chemical relations, and that nothing can be stated about it in this respect, except that it is remarkably similar to barium, but has a higher atomic weight. The further chemical study of radium and other radio-active substances is advocated, and the suggestion is made that material for such work may be obtained from certain rocks, especially granites, occurring in Germany, which are known to contain uranium minerals.—*Berichte*, xxxvii, 1655.

H. L. W.

3. *Detection of Chlorides in the Presence of Bromides.*—Many methods have been proposed for the detection of small quantities of chlorides in the presence of bromides in qualitative analysis, but most of them present difficulties in the hands of students. Chapman Jones has recently proposed for this purpose the treatment of the mixed silver salts with a cold saturated solution of ammonium bicarbonate. The reagent is poured over the precipitate on the filter paper and is acidified with nitric acid after it has run through. When the reagent is allowed to remain in contact with silver salts for a few minutes with occasional agitation, the precipitate produced by acidifying will be greater in the case of the chloride, while the treatment of the bromide may be continued sometimes for half an hour without giving a positive result. In a case of doubt, the acidified liquid may be

divided into two parts; to one is added a slight excess of ammonium bicarbonate solution, and to the other an equal quantity of water. If the turbidity is due to silver chloride, it will dissolve in a few moments, but if it is due to the bromide it will remain undissolved for several minutes, if not for an hour or more.—*Chem. News*, lxxxix, 129. H. L. W.

4. *Solubility of Silicon in Zinc and Lead.*—MOISSAN and SIEMENS have found that silicon dissolves in zinc at a much lower temperature than in lead. In zinc the solubility begins at 550°, and amounts to 1·6 per cent at 850°. In the case of lead the solubility begins at 1100°, and at 1400° it amounts to only 0·15 per cent, while at the boiling-point of lead, about 1550°, it amounts to only about 0·79 per cent.—*Berichte*, xxxvii, 2086. H. L. W.

5. *Analytical Chemistry, Volume II, Quantitative Analysis;* by F. P. TREADWELL: translated from the Second German Edition by William F. Hall. 8vo, pp. 654, with 96 figures. New York, 1904. (John Wiley & Sons, price $4.00.)—A satisfactory text-book for students in quantitative analysis has long been needed, and it appears that the work under consideration will fill this want admirably, and that it will be a most useful book of reference for practical analysts. The most modern and satisfactory methods of analysis are ably presented, and the book is not encumbered with antiquated and superseded processes. The best electrolytic methods are included, as well as methods of fire assaying for gold and silver ores, while separate parts of the book give excellent treatises on volumetric analysis and gas analysis. The modern aspect of the work will be evident when it is stated that the use of the Gooch crucible is strongly advocated (although the details given for its use appear to be unduly complicated, probably from lack of experience with the proper kind of asbestos), and also from the fact that many other American methods, such as those of Gooch and his pupils, Hillebrand, and others, are given. This attitude towards American improvements is in agreeable contrast with the usual conservatism displayed in this respect by European works on analytical chemistry. The translator has also helped in this direction by making certain additions and changes with the object of rendering the book more useful to English-speaking students. H. L. W.

6. *Laboratory Exercises in Physical Chemistry;* by F. H. GETMAN. 12mo, pp. 241. New York, 1904. (Wiley & Sons.)—There has been previously no suitable laboratory text-book in physico-chemical measurements which could be used by the average student, and the present volume has been written to meet this requirement. The customary measurements in physical chemistry are well described in detail, with the apparatus required. Usually but one method is given for each measurement. We notice that in describing the boiling-point apparatus only the Jones form is described, while no mention is made of the Beckmann form. There is a set of convenient tables added at the end of the book. H. W. F.

7. *Chemie der Eiweisskoerper;* von Dr. Otto Cohnheim; Zweite Auflage, Braunschweig, 1904. (Fr. Vieweg und Sohn.)—The publication, in 1900, of a monograph of three hundred pages devoted to the literature of the chemistry of the proteids emphasized the importance which the study of this unique and significant group of compounds has assumed in biological chemistry. The appearance, scarcely four years later, of a new edition of Cohnheim's book, not merely revised but entirely rewritten, gives evidence of the marked progress which has attended recent investigation in this field of study. It is no exaggeration to say that during this interval our ideas regarding the structure of the albuminous bodies have been radically altered in various ways. Investigators and students will therefore welcome the new edition as a useful aid. The judgment which the author has displayed in dismissing with brief reference those theories and facts which no longer possess more than historical interest, and in directing attention to the permanent acquisitions to our knowledge, deserves commendation. From this it will be understood that Cohnheim's book is something more than a mere compilation; indeed, critique is displayed in every chapter. The more important advances appear in the review of the cleavage products of the proteids and in a discussion of their chemical constitution. The almost unavoidable occasional omissions of reference to important papers are apparently few; and the completeness thus attained gives an added value to the work. L. B. M.

8. *Vapor pressure of Mercury at ordinary Temperatures.*—Edward W. Morley gives a résumé of the work of previous observers of this pressure. The work of Regnault must be dismissed from consideration, for his experimental means were not sufficiently delicate and precise. Hagen's measurement also must be disregarded because his interpolation formula is inconsistent with what we know of the behaviour of saturated vapors. The experiments of Hertz, of Ramsay and Young, agree with those obtained by Morley, while those obtained by Van der Plaats differ widely. A table of vapor pressures is appended to the article.—*Phil. Mag.*, June, 1904, pp. 662–667. J. T.

9. *The Penetrating Rays of Radium.*—The γ-rays of radium have been likened to the X-rays on account of their penetrating power and their not being deflected by a magnet. E. Paschen has made a study of this penetrating power. The rays have a very different absorption-coefficient from the X-rays. The author points out incidentally, that the commonly based method of ionizing the air is not suitable for determining the absorption. The rays lose their power of ionizing the air in passing through layers of lead. The γ-rays appear to have a velocity approximating to that of light and they possess great interest; for we apparently have in their case electrical quantities moving with the velocity of light.—*Ann. der Phys.*, No. 6, 1904, pp. 164–179. J. T.

10. *Use of the Thread Galvanometer.*—W. EINTHOVEN described in Ann. der Phys., p. 1059, 1903, a galvanometer which consisted in the main of a silvered quartz fiber stretched between the poles of a magnet. He now explains some further peculiarities and uses of the instrument. He has repeated the Curies' measurement of radio-activity of various substances by the use of his instrument instead of the electrometer and finds it more suitable for the purpose. The currents measured were of the order 5×10^{-11} amp. He also measured insulation resistances of the order of a million megohms. A quantity of electricity 5×10^{-12} ampere-seconds can be detected. In general the instrument is suitable for many uses to which the electrometer has been put; and it is especially useful to detect and measure feeble sounds or telephone currents.—*Ann. der Phys.*, No. 6, pp. 182–192, 1904. J. T.

11. *The Hot Oxide Coherer.*—MAX HORNEMANN states that he described this coherer in 1902, while Branly's paper on the same subject appeared in 1904. Heated and then cooled particles of iron possess, on account of the layer of oxide, a peculiar sensitiveness to electrical waves. The author had shown this property of cold oxide layers and lately has investigated the influence of heat on the sensitiveness of such layers. He found that hot layers of the oxide, if they are of the same metal throughout, do not possess any marked superiority over the cold particles; but if he used layers of different metals, for instance, lead with an oxidized (not noble) metal, he obtained a much greater sensitiveness. With a hot lead copper contact he could detect the purring of a little induction coil at a distance of 12 meters and through intervening walls.

Hornemann has studied this effect of the heated oxide layer by means of a galvanometer and suitable electric circuits; but is not certain of the reason for this peculiar action of heat on the coherer. The property seems to be an important one with reference to wireless telegraphy.—*Ann der Phys.*, No. 6, pp. 129–138, 1904. J. T.

12. *X-Rays and N-Rays;* by R. BLONDLOT.—* * * * The consideration of the kind of symmetry belonging to a Crookes' tube suggested to me the possibility that the rays emitted by it might be polarized on their emission. I proved, in fact, that a small electric spark, subjected to their action, increased in brilliancy when the discharge was parallel to the axis of a Crookes' tube, and that this reinforcement did not take place when normal to the axis. This indicated that the rays emitted had indeed the want of symmetry characteristic of polarization. This point established, I demonstrated at once the existence of rotatory polarization: quartz, sugar, etc., served to rotate the plane of polarization of the radiations produced by a Crookes' tube. I then conceived the idea of trying the rotation by a series of mica plates, after the manner of Reusch: this rotation in fact took place. I was thus led to examine the effect of a single lamina

of mica: this gave elliptic polarization. But the facts stated proved the existence of double refraction and made *à fortiori* simple refraction highly probable. I proved then further that the radiations which I had studied were really deviated by a quartz prism and could be concentrated by a lens; it was also shown that they were reflected by a plate of smooth glass and diffused by an unpolished glass surface.

The facts stated indicate that the rays under examination were not Roentgen rays or X-rays, which suffer neither reflection nor refraction, but a new kind of rays traversing aluminium, wood, black paper, etc., polarized rectilineally on emission, susceptible of rotatory and elliptical polarization, and reflected or diffused, but producing neither fluorescence nor photographic action. To this kind of radiation I gave the name of *N-rays*. It is to the N-rays, in fact, that the phenomena of polarization pertain which I had observed and at first attributed to X-rays. If we analyze by a quartz prism the complex of rays emitted by a Crookes' tube, it is found that the X-rays are not deviated while the N-rays are deflected toward the base of the prism. It is easy then to prove that the N-rays alone act on a small spark while the X-rays seem to have no action on it. I have thus established the polarization of the N-rays and not that of the X-rays; also the velocity of propagation, which I have measured by a method published in these *Archives*, belongs not to the X-rays but to the N-rays. The confusion was unavoidable until the existence of the new radiations was recognized.

A further study of the N-rays has enabled me to prove that any source of light of very small intensity may be employed to show their existence, as a small gas flame, a platinum wire at a red heat, a phosphorescent screen. All of these sources of light have their brilliancy increased by the action of N-rays. A Crookes' tube is not the only source of N-rays; they are emitted also by an electric arc, a Nernst lamp, an Aner burner, and most of all by the sun.

The reflection and refraction of the N-rays follow the same laws as those of light; in particular the law of Descarlis has been verified with a high degree of precision in the experiments made with prisms and lens (of aluminium). In the emission from a Nernst lamp I have proved the existence of a large number of radiations of different indices comprised between the values 1·04 and 1·85. I have isolated the different pencils by the aid of an aluminium prism, I have measured their wave-length by the aid of *reseaux* traced on glass by the classic method, and the method, based upon the use of Newton's rings, has given results agreeing with the preceding. The wave-lengths are comprised between $0^{\mu}·0081$ for the index 1·04 and $0^{\mu}·0176$ for the index 1·85.

It follows from what has preceded that the N-rays are completely analogous to light, from which they differ only in the lengths of the waves, which are much shorter. Now light, ultra-

violet radiation, infra-red radiation and the Hertz radiations, which according to the electro-magnetic theory of light are an extension of light radiations, are propagated with one and the same velocity. In other words, there is a velocity of propagation common to all kinds of radiation and independent of the wave-length. It is thus, as it were, certain *à priori* that the N-rays, all of whose properties approach those of light, and which are surely a variety of it, should have the same velocity. This is precisely what the experiments already described in these *Archives* show. This verification of a fact reasonably sure in advance seems to me not without interest; it confirms the complete unity of character of what we now call the N-rays.—*Archives des Sciences, phys. et nat.*, Geneva, xvii, May, 1904.

13. *Lehrbuch der Physik;* von O. D. CHWOLSON; übersetzt von H. PFLAUM. Bd II., pp. xxii+1056. (Braunschweig: F. Vieweg und Sohn.)—The second volume of this work presents the same admirable qualities as the first volume, which has been previously reviewed in this Journal.* It comprises the subjects of sound and light and is an exhaustive presentation of the phenomena and, so far as is possible with elementary mathematical methods, of the theory also. The descriptive portions are exceedingly clear, the perspective good, and the arrangement so logical that, notwithstanding the great number of details presented, the treatment of the various subjects has a unity somewhat rare in works of this character. A very useful feature is the list, at the end of each chapter, of important original papers bearing upon the subjects treated in the chapter. H. A. B.

14. *Applications of the Kinetic Theory;* by W. P. BOYNTON. pp. x+288. New York. (The Macmillan Co.)—This is a well-arranged collection of the principal theorems and applications of the Kinetic Theory, in which physical ideas are not lost sight of by over emphasis upon the mathematical details. The treatment is, in the main, elementary and the methods employed are those of the founders of the theory, rather than the more general ones developed by Boltzmann and other recent writers upon the subject. The author has succeeded in giving a fairly complete account of the subject without assuming a very extensive acquaintance, on the part of his readers, with mathematics and mechanics; he has avoided the discussion of logical subtleties and delicate questions of rigor which occupy much attention at present, but which the beginner can well afford to do without. The successive chapters deal with ideal gases, gases whose molecules have dimensions, diffusion and viscosity, change of state, the equation of van der Waals, vaporization, liquids, solution, dissociation and condensation, and a summary containing numerical applications, etc. A knowledge of empirical thermodynamics is not assumed, but is given in the text when it is necessary for a comparison between the results of the theory and those of experiment. H. A. B.

*See volume xv, p. 82, Jan. 1903.

15. *Entropy; or Thermodynamics from an Engineer's Standpoint, and the Reversibility of Thermodynamics;* by JAMES SWINBURNE. Westminster. Pp. x + 137. (Archibald Constable and Co.)—This book is the outcome of discussion carried on by the author and others during the latter part of 1903 in the columns of the London Engineering. This discussion has been of great value in calling renewed attention to the importance and difficulties of the thermodynamics of irreversible changes. Mr. Swinburne's contribution cannot, however, be said to be thoroughly satisfactory, unless considered alone for its suggestiveness, and for its rather amusing polemical rigor. In order to put more emphasis on irreversible changes, which are the only real changes occurring in nature, and in order to gain a more physical notion of entropy, he proposes a new order of development of the principles of the science. That these praiseworthy objects have been successfully attained seems doubtful, though the suggestiveness arising from the change in viewpoint cannot fail to be of value to the thoughful reader. The accepted or orthodox (as Mr. Swinburne for controversial purposes prefers to call it) presentation of the science starts with those laws of the transformation of energy which are known as the two laws of thermodynamics; then comes the consideration of the reversible process and cycle from which, by application of the second law, we get the idea of entropy and its conservation; then passing to irreversible or actual processes, we arrive at the notion of the waste in such processes and the growth of entropy. The presentation proposed in this book starts, as does the ordinary treatment, with the same two laws of energy transformation, though Mr. Swinburne unnecessarily mars the presentation by inserting a wholly gratuitous third law, i. e. that a frictionless mechanism is unrealisable; then follows the consideration of the irreversible or actual process, the waste incurred in such processes, the definition of entropy as the measure of the waste, and the doctrine of the growth of entropy; then taking up the ideal reversible cycle, the working definition or mathematical expression for the entropy (or rather for its minimum value) is obtained. Now, aside from the pugnacious manner in which it is presented, and leaving out the unessential and unfortunate "third" law, there can be no valid objection to looking at thermodynamics in this way if one so wishes; in fact, the reviewer feels under a great personal obligation to Mr. Swinburne for proposing this very suggestive alternative viewpoint. When, however, he comes, in the third and fourth chapters, to consider in detail certain irreversible changes, one cannot criticise the author so favorably. There is a lamentable confusion in the matter of the "heat of a body," and, in particular, the restriction of the temperature, in the expression for entropy to the temperature of the envelope, cannot be admitted. A criticism of less moment is that Mr. Swinburne's contention that the state of development of a science is a function of the names it possesses for its units, and that therefore thermodynamics will continue in

a backward condition until his proposal of the "claus" for the unit of entropy is adopted, appears more amusing than convincing.

In conclusion, it may be said that the wish expressed in the last paragraph of the appendix—"that the somewhat novel way of arranging and treating the subject-matter of the groundwork of thermodynamics may meet with the approval of those who specially deal with that science"—will perhaps see a fair measure of fulfillment. The remainder of the subject matter illustrates, in a manner unfortunately not rare, the statement made at the end of the fourth chapter, that thermodynamics "is perhaps the most slippery branch of science there is." L. P. W.

16. *Electricity and Matter;* by J. J. THOMSON, 162 pp. New York, 1904 (Charles Scribner's Sons).—This volume gives in full the six lectures delivered by Professor Thomson at Yale University, on the Silliman foundation, in May, 1903. Those who were so fortunate as to hear this most interesting and suggestive discussion of the nature of electricity and constitution of matter, by one whose own contributions have been of the first importance, will be glad to have the lectures preserved for them in permanent form. The volume also serves the more important end of enabling the gifted lecturer to reach a much larger audience; this, indeed, should include all those who are interested in the progress of science and who, at the same time, have some basis of physical knowledge to make their reading intelligent.

17. *Étude sur les Resonances dans les Réseaux de distribution par Courants alternatifs ;* par G. CHEVRIER. 76 pp. Paris, 1904 (édité par l'Éclairage Électrique). — This is a systematic and homogeneous presentation of a subject, the various aspects of which have been discussed by numerous authors from different points of view. The theory of oscillatory movements in general is given first, followed by a presentation of the theory specialized for the case of circuits with capacity and self-induction. The third part gives the application of the results obtained to the condition of the practical current.

18. *Elektrische Fernphotographie und Ähnliches ;* von Dr. ARTHUR KORN. 66 pp. Leipzig, 1904 (S. Hirzel).—The author here reproduces three memoirs, recently published in the *Physikalische Zeitschrift,* giving an exact description of his methods and apparatus; a historical introduction is added. Those who have not kept up with the progress in this interesting line of experiment will be surprised to see what can now be accomplished.

19. *The Telescope;* by THOMAS NOLAN. Second edition, revised and enlarged, 128 pp., 12mo. New York, 1904 (D. Van Nostrand Company).—To the matter contained in the first edition of this little book, there has been added a new chapter describing the advances made since 1880 and, following this, a bibliography of the important literature on the telescope. The author has succeeded in setting before the reader a large amount of interesting information simply presented and in a very small space.

20. *Scientia, Phys. Mathématique*, No. 23. Paris, 1904 (C. Naud).—This recent number of the valuable series of scientific memoirs now being published in Paris is by H. Poincaré, and is devoted to the subject of the theory of Maxwell and the oscillations of Hertz, with their application to wireless telegraphy. It is an excellent presentation of a very interesting subject.

II. Geology and Natural History.

1. *Glacial Conglomerate, Transvaal, South Africa.*—A proof sheet recently received from the Geological Society of South Africa announces the discovery by E. T. Mellor of extensive glaciated surfaces and deposits 25 miles east of Pretoria. The deposits represent the lower portion of the Highveld Formation, lying immediately below the Coal Measures and "consist of irregularly alternating, usually more or less lenticular deposits of conglomerates, sandstones, and shales. The conglomerates have all the characters usual to ground-moraines. They contain an assemblage of bowlders very miscellaneous in composition and size, embedded in a clayey, or more frequently sandy, matrix full of smaller angular rock fragments. Bedding planes are rarely met with. The bowlders are polished, facetted, and in the case of those composed of material sufficiently fine in grain, frequently striated. The sandstones are also very irregular in thickness, often massive and without traces of bedding; they are white, yellow, or cream-colored, and though often fine in texture, very rough to the touch. The shales are white or cream-colored. They frequently show fine lamination, very regular over short distances, but not persistent over any considerable area. More frequently they partake of the nature of mudstones. These shales are more abundantly developed near the upper portion of the glacial series."

"The glacial deposits were laid down upon a land surface of considerable variety, many features of which reappear with slight modification in the landscape of to-day." Wherever the glaciated deposits are removed by erosion, glaciated surfaces are of frequent occurrence. The striae and bowlders alike abundantly prove that the ice movement was N.N.W. to S.S.E. This direction is in accord with the observations of Rogers and Schwartz at Prieska, Cape Colony (Ann. Report Geol. Com. 1899) and of Schenck near the junction of the Orange and Vaal Rivers (Ueber Glacialerscheinungen in Süd Afrika), but not with the observations of Molengraaff in the Vryheid district (Trans. Geol. Soc. of S. A., IV, pt. V, 1898). The wide extent of the glacial deposits, their presence at various elevations, and the parallelism and constancy of direction of the striae in the Transvaal locality indicates a considerable thickness for the ice sheet.

2. *Wisconsin Geological and Natural History Survey.* E. A. Birge, Director.—Two bulletins of the Wisconsin Survey have recently been published.

Bulletin No. XI.—Preliminary Report on the Soils and Agricultural Conditions of North Central Wisconsin; by Samuel

WEIDMAN. 64 pp., 10 pls., including soil map.—The different classes of glacial drift constitute the principal part of the surface outcrops of Central Wisconsin and these formations are described in detail as to character, water content, etc. Climatic conditions are discussed in Chapter III, (pp. 49–64).

BULLETIN XII.—The Plankton of Lake Winnebago and Green Lake; by G. DWIGHT MARSH. 89 pp., 22 pls.—A comparative study of the Plankton of two lakes of different types has been carried on for a considerable time and many facts regarding the annual and geographical distribution of the animals and plants have been secured. The principles controlling distribution are also discussed.

3. *Geological Survey of Ohio.* EDWARD ORTON, JR., State Geologist. Fourth Series, Bulletin 1. The Occurrence and Exploitation of Petroleum and Natural Gas in Ohio; by J. A. BOWNOCKER. 320 pp., 6 pls., 10 maps.—The history of the Ohio Geological Survey is divided into four distinct periods: 1837–1838, when in charge of W. W. Mather; 1869–1888 under J. S. Newberry and Edward Orton; 1889–1894 when the scope of the survey was somewhat extended, but still in charge of Edward Orton; 1900—when the present State Geologist was appointed and a reasonable appropriation granted by the General Assembly. The investigations now in progress are a revision of the areal and stratigraphical geology, by C. S. PROSSER; and a study of the cement, lime, brick, salt and coal industries by various specialists. The first publication issued by the fourth survey is an elaborate detailed discussion of the history, development, utilization, and future prospects of the oil and gas industry of the state. The descriptions are by townships and include a mass of local geological detail. The origin of oil and gas is discussed in a separate chapter.

4. *Geological Survey of New Jersey*, HENRY B. KÜMMEL, State Geologist. Annual Report, 1903. 128 pp., 14 pls.—The work of the New Jersey Survey shows progress along several lines of activity. It has been decided to replace the present topographic map with a new system of non-overlapping sheets. Professor Salisbury is to prepare a report on the surface geology of the southern part of the state. Dr. Weller reports that the Cretaceous presents definitely recognizable faunal zones traceable entirely across the state. Dr. Eastman has made arrangements to complete his studies of the Triassic fish at once. In addition to the usual reports on underground water, mineral resources, etc., a special report is made by C. C. Vermeule on the Passaic floods and a scheme for their control by a throttling dam at Little Falls.

5. *Delta Plains in the Nashua Valley.*—The extensive excavations and borings made by the Metropolitan Water Board in the region of glacial Lake Nashua have furnished unusual opportunities for the study of glacial deposition. In the Technology Quarterly, xvii, No. 1, W. O. CROSBY describes in detail the structure and composition of the delta plains of the Clinton stage and their associated deposits.

6. *The Floods of the Spring of 1903 in the Mississippi Watershed;* by H. C. FRANKENFIELD. U. S. Weather Bureau Bulletin M, 63 pp., 15 charts.—The Mississippi Floods of 1903 exceeded in height any high water on record from Memphis to the Passes. The greatest destruction was at Kansas City, but the villages along most of the western tributaries of the Missouri were affected. As a study of abnormal rainfall and run-off this bulletin is of much value.

7. *Catalogue of the Ward-Coonley Collection of Meteorites;* by HENRY A. WARD. 113 pp. with 10 plates. Chicago, 1904.—It is certainly most remarkable in the history of meteorites that a collection, which is now the largest in the world in number of falls and stands in the first rank with the great collections of Vienna, London and Paris, should have been brought together through the activity and enterprise of one collector and that within a period of ten years. This is true, however, of the Ward-Coonley Collection, the third catalogue of which is now issued. Mr. Ward had already brought together two earlier collections of 170 and 200 falls, respectively, and it was not until 1894 that the present collection was begun. It now numbers 603 falls, with a total weight of about 2500 kilos. During the past four years the increase has been at the rate of 45 falls per year; the catalogue of 1900 showed 424 falls (1399 kilos) and that of 1901 gave 511 falls (1786 kilos). The collection is not simply remarkable in the number of occurrences, but also in the relatively large size of many of the individual specimens. A list, for example, is given of 30 falls, about equally divided between irons and stones, of which the largest single piece is now preserved in the Ward-Coonley Collection. In addition to this point, the introduction of the catalogue calls attention also to some of the remarkable features of the individual specimens and deserves to be studied in detail. The collection is at present placed on deposit in the Geological Hall of the American Museum of Natural History in New York City. The catalogue is handsomely printed, giving not only the locality, details in regard to weight, etc., but also the character of each specimen, as indicated on the scheme of Brezina detailed on a later page. In addition to the main chronological list of the collection, an alphabetical list of all known meteorites with synonyms is given, also a list showing geographical distribution. A series of half-tone plates show some noteworthy specimens, also representations of a number of polished surfaces of the irons, with the figures developed by etching.

8. *Harvard Experiment Station in Cuba.* G. L. GOODALE.—The generosity of Mr. Edwin F. Atkins, of Boston, has placed at the service of the Botanical Department of Harvard University a tract of land and certain buildings near Cienfuegos, which are now employed actively in the attempted solution of a few problems in applied botany. The grounds were first utilized for this purpose a few years ago, when preliminary trials in the artificial production of sugar cane seed were undertaken. For a

short time previous to this, an extensive collection of all the approved varieties of cane then accessible was brought together, and this has been enlarged from time to time, until the sorts now have a very wide range.

From the outset, a good deal of attention was paid to the acquisition of the best kinds of other useful plants, especially those which are adapted to the tropics or those northern plants which can be made to grow more luxuriantly in very warm regions. The establishment was so fortunate as to secure early the services of Mr. C. G. Pringle, as botanical collector. He has devoted much time, with good success, to the selection and forwarding of desirable species from Mexico.

By the end of last year, the number of species had increased so considerably that a new and thoroughly skilled superintendent was placed in charge of the grounds. Mr. Robert M. Grey, the new superintendent, is widely and favorably known as an accomplished hybridizer. He has had placed at his disposal ample facilities for prosecuting his experiments in many directions.

The principal directions of these researches are the following:

(1) Securing the best varieties of cane, by selection and by seeds. In this part of the work, the fullest opportunity is given for the prompt and exact determination in the chemical laboratory of the station, of the sugar-content. Some of the more interesting results have already been published.

(2) Selection and improvement of cotton, ricinus, pineapple, etc., with definite relation to the resistant power of the varieties.

(3) The cultivation of the line of vegetables demanded by the large estates, and finding also a ready market in the cities. This line of study has proved useful and is likely to be more and more highly appreciated by the smaller cultivators with limited capital. This series of studies is placed on an exact basis with regard to cost and profit, in order that the results may be a safe guide to the small farmers and gardeners.

One of the most useful functions of the station has been to show the necessity of extreme caution in entering on large plantings of certain plants which have relentless enemies in the neighborhood, for instance, as a special case, cotton of the usual sorts.

The station was visited winter before last by Mr. J. C. Willis, director of the Royal Botanic Gardens at Perideniya, Ceylon, who has aided us much by his advice. From many sources most generous coöperation has been obtained, and the interesting experiment is now fairly in hand. To indicate somewhat more fully the general nature of the enterprise, I select portions from the latest report of Mr. Grey, which refer especially to the sugar cane, caladiums, pineapples and ricinus.

9. *Report of the Harvard Botanical Station in Cuba for the Month of May, 1904;* by ROBERT M. GREY.—The meteorological observations for the month are as follows: temperature max., day 91°, min. 73°; night 76° and 64°; humidity of the atmosphere 85° to 100°; rainfall 18·04″, for May, 1903, 8·14″.

During the month of May the temperature has been below normal, usually ranging between 82° and 87°, never above 90° during the hottest part of the day. The mornings and evenings have been cool and pleasant with a fine breeze, south to southeast winds prevailing. The barometer has been steady, ranging from 29·87″ to 29·90″. The humidity of the atmosphere has been greater than for the month previous.

The rainfall for the month has been abnormally large. A heavy storm of May 1st lasted about twenty hours, during which time 5·50″ fell, swelling the arroyas and streams to an enormous height, washing out some of the spring planting, and causing much extra work in the garden, which suffered severely. The stream rose eight feet, carrying away some of our botanical plants, which were situated along its margin, and many choice lilies, besides the represser and one bridge. Another severe rainstorm of 4·04″ visited us on May 7, causing a still greater flood, ruining completely bridges, walks and nearly everything along the water course, including our stock Platinal of about ten varieties, some pineapples, fancy caladiums, a part of the tea, Liberian coffee, cocoa, callas, etc.

. . . . Special effort is devoted to propagating, weeding, cleaning and planting shrubbery in our new nursery. We already have a fair lot of laurels, crotons, acalyphas, limes, and about five hundred roses planted out, and much small stock of various kinds which will be transferred later.

The sudden change from dry to wet weather has caused black spot among a few things, such as roses, lettuce, and other stock.

Among the quantities of sugar cane seeds sown this season (over four hundred heads) we have had very poor results. Probably not more than eight or ten seeds in all germinated, and, excepting a single plant, which is still too young to determine positively, these have all died. The remaining one is making a good growth. It came up among seeds of Crystallina collected among the Cinta in the "Chino" and without artificial hybridization. A small portion, each of one hundred heads, was selected and planted together in our small Platinal (since injured by water). The plant germinated about April 27. It has grown rapidly and is now about four inches high, with three fairly characteristic leaves.

I am of the opinion that Cuba is the northern boundary where sugar cane produces flowers, and it therefore seldom perfects seeds of good germinating power in Florida and Louisiana; very little farther north it does not even flower. The flowers on our cane here are perfect and the seeds in many cases reach normal size and appear good, but are very soft and delicate. They are, however, a month later than in the more southern warmer islands and thus do not always have the benefit of the late fall rains to perfect them; no doubt, however, in a succession of years we shall occasionally find favorable seasons in which better luck may attend our efforts.

The new spring plantings of experimental canes came up regular and healthy and are growing well. The varieties of which we had but one or two stock plants have been divided up and transplanted with the rest of the collection, thus bringing all of the experimental canes together in one patch. Since the arrival of the wet weather, what appeared to be "Sereh" or Fan disease on one or two of our Java canes has disappeared, the fanlike appearance being nothing more than stunted growth. Several, however, which showed a lack of chlorophyl in the leaves and were sickly in the roots (probably through weakness) have not grown out of it and will be destroyed as a preventive.

Careful observation among the cane in the field has not brought to light disease of any kind; several plants which had "Rind Fungus" on the dead stock during the early spring and which were marked by us, upon careful examination fail to show traces of any disease in the young canes. They are perfectly healthy and vigorous, which I believe conclusively indicates that the Rind-disease fungus takes possession of dead tissues in exhausted or dead canes when of no further use to the plant.

On December 4, I cross-hybridized Red Spanish and Cuban Queen pineapples; on May 18, when the fruit ripened, I found that not one had perfected any seed. This may be due to the dry season, and I shall experiment further during the wet season when flowers again begin to open. We have disbudded a large per cent of the Cuban Queen pineapples and a great improvement is discernible. The fruits grow larger and mature more rapidly, the flavor is improved and the tissue is softer. This variety usually produces ten to twenty shoots around the base of the fruit, which continue to grow and rob them of the sap essential to their proper perfection. Where disbudding is not resorted to (at least in the winter crop) they take a much longer time to ripen, and they lack flavor.

Colacasia antiquorum, known here under the name of "Malanga" or Tania, is one of the principal articles of food. It is boiled in a similar way to sweet potatoes or "Bonata" and much preferred to it. There are three distinctly marked varieties. The type has dull glaucous green leaves and stems somewhat tinged with purple, and the leaves are rather sharply defined. This is the one commonly cultivated in this vicinity. It is rather insipid in flavor and does not multiply very quickly in the field. The Castilian Malanga, Colocasia antiquorum var. esculentum, is identical with our northern Caladium esculentum; it is of a yellowish color, has a sweetish flavor when cooked, and is much preferred by the laborers. The plant is a stronger and more rapid grower, the leaves are large, irregular, pale green, scarcely glaucous, and the leaf stock is only faintly glaucous. It produces from one-third to one-half more "bulblets" per annum. After giving these two varieties a fair trial I am convinced that the old type can be gradually discarded in favor of this one, and have set out about five thousand in the soltadera for the coming

season, along with as many of the others. They already show a superior growth. This variety is also a valuable florists' plant, and large "bulbs" bring a good price in the market; they could, if desired, be grown here in quantity and at a very fair profit.

The third variety is at present rather scarce, it is a larger and taller grower than either of the above sorts, with a vigorous constitution, but makes very few offsets and does not perfect them so quickly; the flavor is also rather inferior to C. esculentum. The fancy bright foliage Caladiums (closely related to the above) of the C. Schomburgkii, C. Marmoratum, C. bicolor, and C. picturatum type with their hybrids and varieties, grow and increase freely here, and although the market is somewhat limited they can be profitably grown. They do best in a rich humus and require some shade in order to mature big "bulbs" quickly.

The castor-oil plants (Ricinus Zanzibariensis var. Nigra) sowed January 10 ripened their first fruit May 29, and promise a good crop. This is the large black African bean; it is not quite so high in percent of oil as the small native bean, but is several times larger, superior in every other respect, and equally productive, which will more than compensate for this slight difference. The shell is softer and more easily crushed and pressed than the native variety; it also has an advantage over nearly all other varieties in the fact that it is self-shelling in either fire or sun-heat, while the native one is not. As a proof of this, I took samples from thirty separate plants and did not find one in which they were self-shelling. Some of the varieties of Arborea and Borboniensis are better in this respect, but I have not been able to test them thoroughly yet.

[The remainder of the report deals with cotton, and with certain vegetables.]

10. *Catalogus Mammalium, tam viventium quam fossilium;* a Doctore E.-L. Trouessart. Quinquennale Supplementum, Anno 1904. Fasc. I, pp. iv, 288. Berlin (R. Friedländer u. Sohn).—The successive parts of the second edition of this great work have been repeatedly noticed in these pages. The edition was completed in 1897 and an appendix was issued in 1899. A new method has now been adopted to bring the work up to date, viz., the publication of a five-year supplement complete in itself and forming, in fact, a third volume of the *Catalogus;* of this supplement the first part is now issued. The arrangement is such as to show at once what new species have been added and to what groups they belong.

III. Miscellaneous Scientific Intelligence.

1. *Publication of the Earthquake Investigation Committee in Foreign Languages*, No. 16, 117 pp. Tokyo, 1904.—A detailed discussion is here given by A. Imamura of the Milne horizontal pendulum seismograms obtained at Hongo, Tokyo, of earthquakes, about 300 in number, which occurred from July, 1899, to Dec., 1902. Of 49 large earthquakes, 30 of which originated

outside of Japan (East India, Gulf of Mexico, Alaska, etc.), and 19 within Japan, the majority were submarine, only two of the Japan earthquakes having been inland ones. From the observation of these large earthquakes, the average transit velocities of the different phases obtained are as follows: V_1=13·2 km. per sec., V_2=6·8, V_3=4·5, V_4=3·3, V_6=2·8, V_7=2·4, V_8=2·1.

2. *Ready Reference Tables*, Volume I. Conversion factors of every unit or measure in use, including those of length, surface, volume, capacity, weight and length, etc., based on the accurate legal standard values of the United States. Conveniently arranged for engineers, physicists, students, merchants, etc.; by CARL HERING, M.E. 16mo, pp. xviii + 196. New York, 1904 (John Wiley & Sons).—The great value to the practical worker of a volume of tables, such as the present, is so obvious that it hardly needs to be insisted upon. The arrangement and typography here are excellent, while the condensed list on the opening pages and the index add much to convenience of use.

3. *University of Chicago: Decennial Publications.*—The first series of these publications consist of ten quarto volumes, viz.: two volumes of reports and eight volumes of investigations representing the research work in the different departments of the University. From volume ix, devoted to mathematics, physics, chemistry, geology, the following memoir, recently issued, is separately printed: The subgroups of the generalized finite modular group, by Eliakim Hastings Moore.

4. *Field Columbian Museum.*—Recent publications include the following: No. 2 of vol. III of the Botanical Series, by Charles Frederick Millspaugh and Agnes Chase, devoted to the plants (Compositæ) of the Peninsula of Yucatan; No. 16, vol. III, Zoological Series, by D. G. Elliot, on mammals collected in Southern California by E. Heller; also No. 3, vol. II, Report Series, giving the Annual Report of the Director for 1902–03.

5. *Publications of the Bureau of Government Laboratories at Manila.*—Bulletin No. 1 of the Entomological Division of the Biological Laboratory, by Charles S. Banks, entomologist, recently issued, discusses the Insects of the Cacao, especially for the benefit of farmers.

OBITUARY.

SIR CLEMENT LE NEVE FOSTER, F.R.S., professor of mining in the Royal College of Science in London, died on April 19, at the age of sixty-three years.

PROFESSOR ALEXANDER W. WILLIAMSON, the venerable English chemist, died on May 6, at the age of eighty years.

Mr. FRANK RUTLEY, the well known English petrologist, died on May 16 at the age of sixty-two years.

PROFESSOR ÉMILE DUCLAUX, the eminent French bacteriologist, died early in May in his sixty-fourth year.

PROFESSOR CHARLES SORET, of Geneva, well known for his work in experimental physics, died on April 5th, at the age of fifty years.